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ORIGINAL ARTICLES.

The Siluro-Devonian Junction in England.[1]

By Thomas Robertson, B.Sc., Ph.D.

Introduction.

The selection of a base for the Devonian System has evoked much controversy, and summaries of the literature are given in several papers.[2] The subject has acquired a new significance recently through the work of Ch. Barrois and his coadjutors in the north of France, and that of W. W. King[3] and L. D. Stamp in England. The matter has been argued at length in the papers referred to, and it is impossible to appreciate all the factors involved without reference to them.

Recent work by the author, in various parts of the Welsh Borderland, has led him to adopt the conclusion (Ch. Barrois, L. D. Stamp, etc.) that the base of the Ludlow Bone Bed is by far the best horizon to take as the Siluro-Devonian junction. The problem, however, though ably discussed, has not been clearly reviewed in the light of some of the most important fundamental principles. There is also some additional information of more recent date available, both in this country and on the continent.

Perhaps apology is necessary for returning to this subject so soon after the publication of L. D. Stamp's detailed discussion referred to above; but the present writer is not able to accept certain statements in that discussion, and does not wish to be associated with certain of the main reasons given for the selection of the Ludlow Bone Bed. It is therefore thought best to present a short statement on the subject in so far as it concerns the actual selection of a horizon for the Siluro-Devonian junction.

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[1] Communicated by permission of the Director of H.M. Geological Survey.

[2] Schuchert, C., *Bull. Geol. Soc. Amer.*, vol. xi, 1900, p. 241. H. S. Williams, ibid., p. 333. H. de Dorlodot, *Ann. Soc. Geol. de Belgique*, tom. xxxix, 1912, p. M 291. Ch. Barrois, P. Pruvost and G. Dubois, *Mem. Soc. Geol. du Nord*, tom. vi, fasc. 2, 1922 (for 1920), p. 163. L. D. Stamp, Geol. Mag., 1923, p. 276.

[3] *Proc. Geol. Assoc.*, vol. xxxvi, 1925, pp. 383–9.

HISTORICAL REVIEW.

Since our decision must depend upon the present state of research in the regions where Siluro-Devonian rocks have been investigated, a brief historical review is necessary. De Dorlodot has discussed the historical side in great detail, and L. D. Stamp has reviewed the matter somewhat fully as regards the Welsh Borderland; but it is impossible in a detailed historical discussion to view the subject in correct perspective. It will, therefore, be best to give, first of all, an outline of how the actual mapping of the British Siluro-Devonian rocks has proceeded in the past; laying stress upon the important factors involved.

Murchison's original upper limit for the Silurian was the Ludlow Bone Bed. Later he extended the Silurian System to include the grey measures (Temeside Group) that occur above the Bone Bed at Ludlow and also the Tilestones and the beds below them at Llandilo (Fig. 1); since he considered that their fauna was allied to that of the beds below the Bone Bed at Ludlow. The Welsh Borderland was therefore mapped on that view, and the top of the Silurian was drawn in a position estimated to include the Temeside Shales in Shropshire and the Tilestones in South Wales. It was obvious, however, that the line was not a true horizon, but depended on how high up into the red marls any characteristic members of the Ludlow fauna extended. The fact that no endeavour was made to subdivide the great series of red marls between the Silurian and the Brownstones also tended to leave the whole question obscure.

In Scotland the discovery by R. Slimon of a eurypterid fauna below the Old Red Sandstone in the Lesmahagow district of Lanarkshire, led to the publication of an account of that area by Murchison.[1] He writes as follows:—"The last of the decidedly dark grey and schistose beds . . . are those in which all the fossils described . . . were found by Mr. Slimon. These dark fossiliferous rocks . . . are immediately overlaid by and pass up into red sandstone, in which there are several alternations of more or less greyish or greenish-grey bands. . . . I did not observe any unconformity between the grey beds with Crustaceans and other fossils and the overlying red sandstones, the lowest courses of which are marked upon Mr. Slimon's map as 'Red Silurians'. For my own part, however, I would rather consider these red strata as constituting the base of the Old Red Sandstone, because they graduate up into and alternate with pebbly conglomerates which are largely developed near Ach Robert and Waterside." The mapping, both here and in the Pentland Hills, was carried out in accordance with this view; but it was found that the "pebbly conglomerates" in the Pentlands lay with strong unconformity upon the underlying beds.[2] When the Lesmahagow district was mapped by B. N. Peach it was found that the red and yellow sandstones overlying the fossiliferous grey beds contained certain green and red mudstones with bands of grey shale and greywacke. These yielded some obscure crustacean remains.[1] During the revision of the Scottish Silurian rocks by B. N. Peach and J. Horne [2] a crustacean, eurypterid, and fish fauna similar to that in the beds assigned to the Ludlow was found in

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[1] *Quart. Journ. Geol. Soc.*, vol. xii, 1856, pp. 15–25.

[2] See A. Geikie, *Quart. Journ. Geol. Soc.*, vol. xvi, 1860, p. 312, and "The Geology of Edinburgh" (*Mem. Geol. Surv.*), 1861, pp. 4–7.

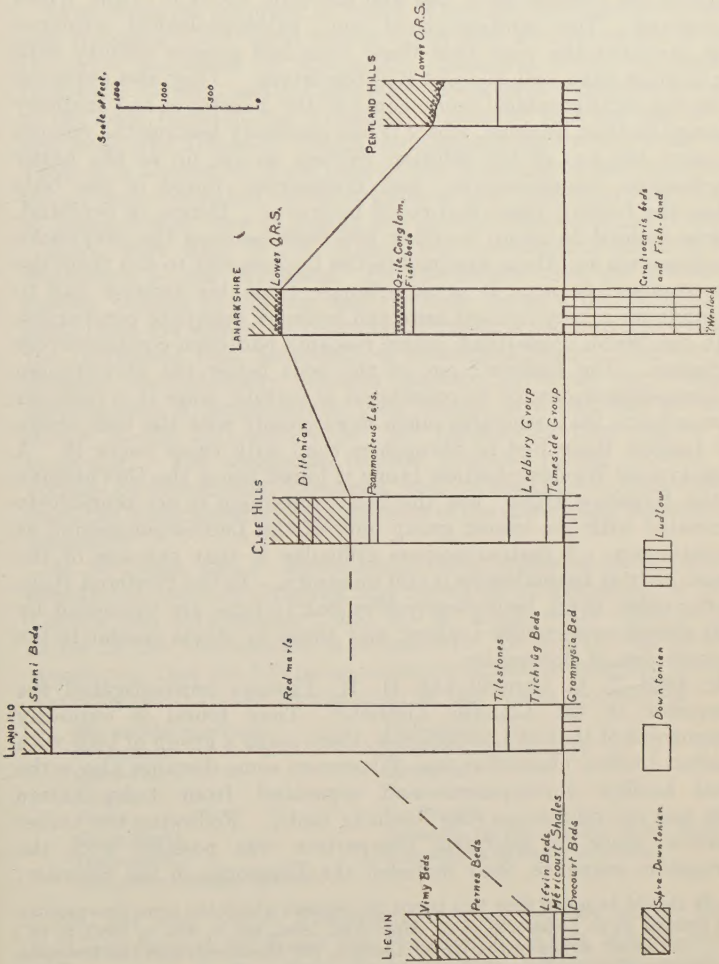

FIG. 1.—Comparative Vertical Sections of the Downtonian Rocks of Great Britain and Northern France.

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[1] "Explanation of Sheet 23" (*Mem. Geol. Surv. Scotland*), 1873, p. 13.

[2] "The Silurian Rocks of Britain, vol. i, Scotland" (*Mem. Geol. Surv.*), 1899, pp. 64–9 and 564–606.

these grey beds (Fig. 1). The fish fauna, however, was different from that found in the Lower Old Red Sandstone above the greywacke conglomerate that indicates the horizon of the unconformity in the Pentlands. On the other hand, it was similar to the fish fauna of the Ludlow Bone Bed and the beds above it in the Welsh borderland. The stratigraphical and palaeontological evidence thus favoured the view that these beds had greater affinity with the Silurian than with the Old Red Sandstone. They also appeared to be the stratigraphical equivalents of the Tilestones and Ledbury Passage Beds in England, where it had gradually become the custom to carry the top of the Silurian System as far up as the horny brachiopods, lamellibranchs, and crustaceans found in the beds below the Ludlow Bone Bed could be traced. Hence, in Scotland, it was decided to group together the beds between the greywacke conglomerate and those assigned to the Ludlow and to call them the Downtonian[1] Series. It is unfortunate that this decision had to be made on a very limited area and without adequate comparison with the Welsh borderland, where research had been comparatively neglected. The Ludlow[2] age of the beds below the Downtonian at Lesmahagow cannot be considered as certain, since it is deduced from a fauna that compares much more closely with the beds above the Ludlow Bone Bed in Shropshire than with those below it. A more typical Wenlock-Ludlow fauna is found below the Downtonian of the Hagshaw Hills; but the beds containing it are tentatively correlated with the lowest group only of the Ludlow succession at Lesmahagow. A further serious difficulty is that the age of the lowest beds at Lesmahagow is still unknown. In the Pentland Hills, on the other hand, beds clearly Wenlock in type are succeeded by beds almost as certainly Ludlow, and these by strata similar to the Downtonian of Shropshire.

In 1901 T. C. Cantrill and H. H. Thomas reinvestigated the succession in the Llandilo district.[3] They found it curiously reminiscent of that at Lesmahagow, there being a group of beds with residual Ludlow characters (the Tilestones) some distance above the usual Ludlow development and separated from it by barren grits and red mudstones (the Trichrûg Beds). Following the earlier practice, since no adequate comparison was possible with the Shropshire sequence, they included the Tilestones in the Silurian;

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[1] It should be noted that this is not the sense in which the term Downtonian was defined by C. Lapworth, *Ann. Mag. Nat. Hist.*, ser. v, vol. v, 1880, p. 48: "... the sandy strata of the Upper Ludlow, the Bone-beds and the Downton Sandstone. For the sake of distinction these may collectively be termed the *Downtonian* formation." This definition has been adhered to subsequently by certain other authors.

[2] In the literature of the subject the term Ludlow includes in some cases the grey beds above the Ludlow Bone Bed but in others it does not. In this article Upper Ludlow means the beds between the top of the Dayia Shales and the base of the Ludlow Bone Bed.

[3] "Summary of Progress" for 1901 (*Mem. Geol. Surv.*), 1902, p. 36; and "The Country around Ammanford" (*Mem. Geol. Surv.*), 1907, pp. 37–52.

but, as no break was found in the sequence higher up in the marls of the Old Red Sandstone, everything above the Tilestones was put into the Old Red Sandstone. Nevertheless, it was found that beds higher in the sequence than the Tilestones took on Tilestone characteristics further west, but these yielded no fossils.

Even when the mapping in South Wales had extended to Marloes and Wooltack Bays there was no up-to-date account of the Siluro-Devonian succession in Shropshire. This was partly supplied in 1906 by G. L. Elles and I. L. Slater.[1] They gave a detailed account of the beds between the Aymestry Limestone and the top of the grey beds (the Temeside Group) that succeed the Ludlow Bone Bed. They took the top of these beds as the Siluro-Devonian boundary; but as their researches ended upwards at that point it is not possible to consider their view as having any direct influence on the problem.

Since that time W. W. King[2] has investigated the Old Red Sandstone of the Midlands. He has shown that the lower and greater portion of the red marl division yields a Downtonian fish fauna, and the higher, or Dittonian, division a fish fauna like that of the Lower Old Red Sandstone of Peach and Horne. There is not, however, unconformity between the two divisions, nor even the development of conglomeratic beds, though at Brown Clee the sandstones of the Dittonian beds "are remarkably false-bedded and lenticular. The cornstones contain irregular pieces, pebbles, and nodules of fine-grained limestone, such as might have been derived from the denudation on the shore-line of the underlying *Psammosteus* limestone".[3]

B. N. Peach and J. Horne had already indicated their views on correlation between England and Scotland by adopting the terms Ludlow and Downtonian; and W. W. King's work upholds these as far as the Downtonian is concerned: He points out, in correspondence, that the following members of the Downtonian fauna of Scotland occur in the Downtonian of the Welsh Borderland:—

Fucoid-like markings.
Pachytheca.
Spirorbis.
Lingula.
Parka.
Ceratiocaris.
Dictyocaris.
Eurypterus (many species).
Pterygotus.
Stylonurus (abundant).
Birkenia.
Cephalaspis.
Cyathaspis.
Lanarkia (in the Ludlow Bone Bed).
Thelodus (extremely common).

He has also found *Pharyngolepis*, and list-like scales similar to those figured by Kiaer for *Pterolepis*.[4] Kiaer himself records *Eurypterus pygmaeus* Salt. from Norway. These examples are interesting in view of the general correspondence between the Downtonian faunas of Norway and Scotland. Kiaer's review of the question[1] is of importance.

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[1] *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 195.

[2] Op. cit.

[3] Ibid., p. 386.

[4] "The Downtonian Fauna of Norway," *Vid. Selsk. Skrifter*, Kristiania, 1924, No. 6, fig. 29.

There seems thus to be sufficient correspondence in fauna to make the identity of the Downtonian of England and Scotland reasonably probable. Added to this, we find that these beds, in both countries, are the strata lying between the Upper Ludlow with characteristic brachiopod and other fauna, and the *Pteraspis* and *Cephalaspis*

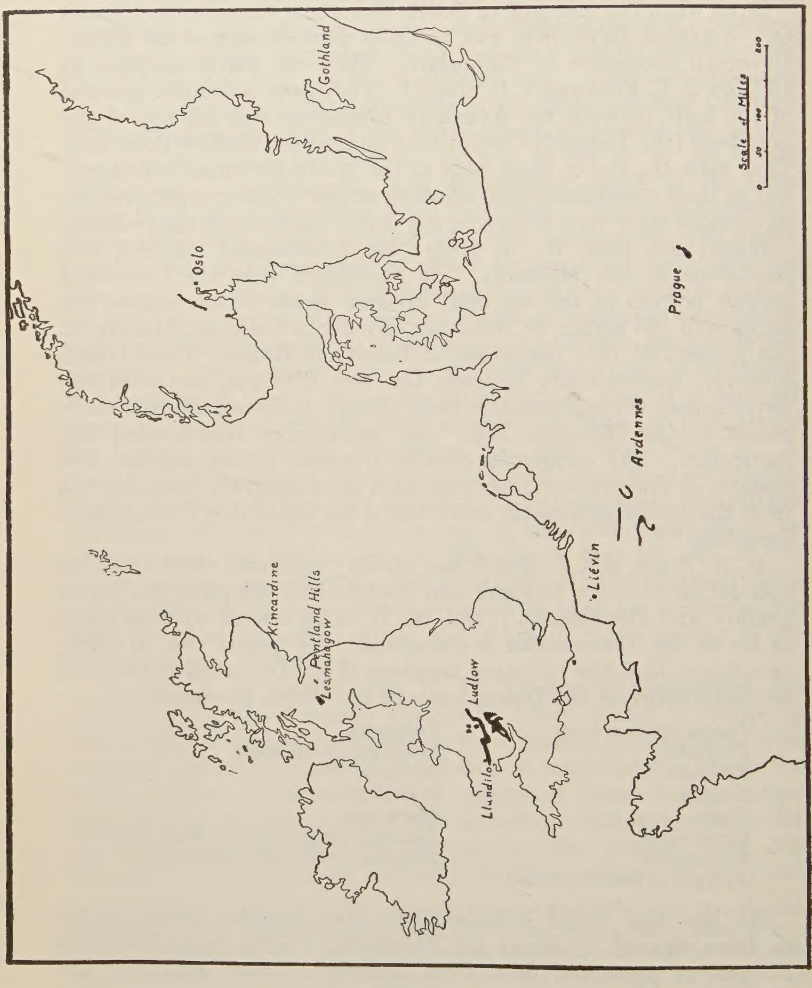

Fig. 2.—Map showing chief Outcrops of Downtonian Rocks in Western Europe.

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[1] Op. cit., pp. 18–20.

lyelli beds of the Lower Old Red Sandstone (Scotland) or Dittonian (England). There is also a distinct lithological similarity, so that there seems every justification for considering that the Downtonian of England and of Scotland are the same formation.

In 1912, M. Leriche[1] reviewed the Lower Gedinnian of the Ardennes, which rests unconformably upon beds up to Lower Ludlow in age. He claimed that it contains an "Upper Ludlow" fauna and so should be placed in the Silurian. If the Downtonian be Silurian this is just, for Ch. Barrois, etc.,[2] have since shown that the Lower Gedinnian is equivalent to the Downtonian alone, and does not include any portion of the Upper Ludlow.

In the work referred to, Ch. Barrois, P. Pruvost, and G. Dubois have shown that, in the Liévin district, rocks with a fauna of Upper Ludlow type pass upwards into others containing a fauna of Lower Devonian type (Fig. 1). These are succeeded by beds with the Lower Old Red (Dittonian) fauna of Peach and Horne. They make it clear that the Downtonian of Britain is the equivalent of the Lower Gedinnian of Liévin; for both are underlain by beds with an Upper Ludlow fauna and succeeded by beds with a Lower Old Red Sandstone (Dittonian) fauna. In their review of the whole problem they decide in favour of Murchison's original base, namely the Ludlow Bone Bed, maintaining that the only really decisive factor in the case is that of priority.

L. D. Stamp,[3] after original work and critical review in the Welsh Borderland, takes this same base for the Devonian, maintaining that there are decisive positive reasons for its acceptance throughout Western Europe. Mea ntime, B. N. Peach and J. Horne's view, being until recently the only modern authoritative statement, has been that most widely accepted abroad.

J. Kiaer's work in Norway,[4] following as it does the Scottish classification of 1899, uses the terms as therein defined. If the Downtonian and highest Ludlow are not Silurian but Devonian, Kiaer's conclusions are not affected. In Gothland[5] (Fig. 2) the highest known beds contain an Upper Ludlow marine fauna, and unless higher beds of different character are found above them it seems impossible to get any light on the problem from that region. The *Cyathaspis* recorded by Lindström[6] from Lau would appear by Hede's mapping to have been found in the Lower Ludlow, and thus to be strictly comparable with the *Cyathaspis* found at Leintwardine (see p. 397).

In Bohemia, work by J. Perner and O. Kodym[7] shows that

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[1] *Mém. Mus. r. Nat. Hist. Belg.*, vol. vi, 1912, pp. 57–8.

[2] Op. cit.

[3] Op. cit.

[4] Op. cit.

[5] Hede, J. E., *Sver. Geol. Unders. Arsbok.*, 14 (1920), No. 7, 1921.

[6] See *Geol. Mag.*, 1895, p. 170.

[7] *Amer. Journ. Sc.*, ser. v, vol. iv, 1922, p. 53.

Downtonian fish appear immediately above beds containing a fauna resembling that of the Upper Ludlow. Graptolites, however, are present at still higher horizons.

In Maryland the fauna of the highest Silurian beds, as investigated by C. K. Swartz,[1] shows a remarkable similarity to that of the Upper Ludlow. It is succeeded by the Helderberg division, strongly resembling the Konieprusian in fauna,[2] and now generally accepted as the lowest Devonian of North America.

CONSIDERATIONS GOVERNING THE SELECTION OF A HORIZON.

In a question chiefly of taxonomic interest priority must be an important factor, and Murchison's original upper limit to the Silurian has precedence other things being equal. The strength of the priority argument is greatly weakened, however, by the fact that there is no comparison whatever between the scant knowledge on which the original decision was made and the abundant evidence now available. Whether the top (Murchison) or the bottom (Page, Barrois, etc.) of a bed usually less than 6 in. thick is taken as the datum is not of great importance from the standpoint of priority; provided that priority is only a subsidiary criterion. If, however, it is taken as the principal or as the sole permissible criterion, the actual horizon is of much greater importance, and the distinction between the top and bottom of even a thin bed is vital.

Another desideratum in the junction of two systems is that it should be, as far as possible, easy to map, since the chief reason for founding systems and formations is that they may aid in comparative study throughout extensive regions. In this the Ludlow Bone Bed has very distinct advantages as compared with any other horizon that has been suggested, in that it can be readily and accurately located in the field. The impossibility of mapping the top of the "Tilestones"[3] with any approach to accuracy is amply illustrated in the older maps of the Survey, where it was taken as the base of the Old Red Sandstone. Again, the top of the Downtonian, though probably sufficiently definite in England for mapping, is not identifiable with anything like the precision that can be attained in the case of the Ludlow Bone Bed.

As, however, the main geological divisions are stratigraphical in nature, the above considerations are necessarily subordinate to positive stratigraphical factors. The characters that are most important in a horizon that is to be taken as the junction of two systems are: (1) definiteness, (2) wide superficial extension, (3) uninterrupted depositional sequence, (4) rapid change in fauna, and (5) facility of correlation between calcareous marine and deltaic facies. Perhaps some of these conditions are almost of necessity mutually exclusive, but no horizon is likely to prove really serviceable unless it meets them to a considerable extent.

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[1] *Maryland Geol. Surv.*, "Silurian," 1923, p. 45, etc.

[2] Schuchert, op. cit., pp. 264–5.

[3] This unfortunate word has been the cause of much confusion and should be abandoned for everything except the Tilestones of the Llandilo area and beds proved to be identical with them. We have still no convincing demonstration of their relationship to the Shropshire sequence.

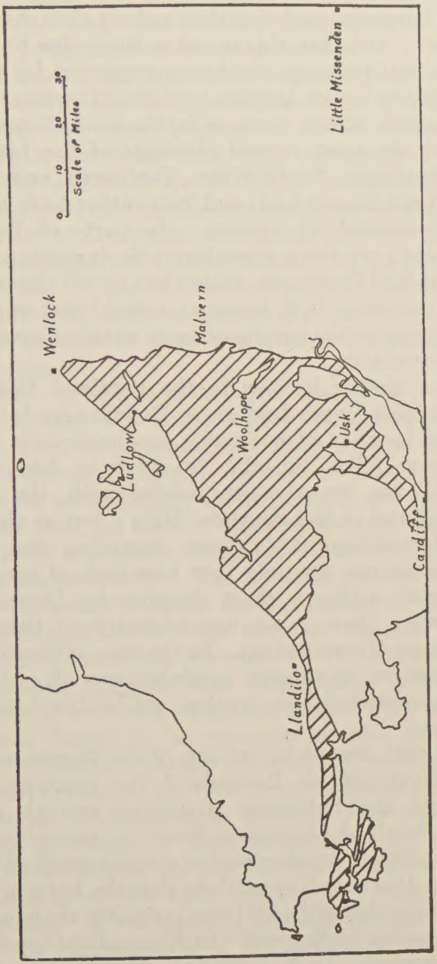

Fig. 3.—Map of the Old Red Sandstone of the Welsh Borderland.

Enough has been said in the papers referred to at the beginning of this article to make it clear that the Ludlow Bone Bed and the top of the Downtonian are the only horizons that merit serious attention. Their relative value may be judged by reviewing them in the light of the considerations already mentioned.

(1) *Definiteness.*—This is a condition that applies only to the area over which the horizon can reasonably be presumed to be identical—in the case of the Ludlow Bone Bed over the area in which marine Silurian sediments are succeeded by predominantly outer deltaic deposits of directly derived terrigenous material. Where this horizon exists in England and Wales we find a typical Upper Ludlow fauna succeeded within a short distance by a typical Downtonian one ; and that this is not entirely due to change from one physiographical state to another is suggested by the fact that any reversion to the Upper Ludlow type of sedimentation higher up is not accompanied, except perhaps in the Sawdde section, by the reappearance of the most typical elements of the Ludlow marine fauna. In Westmorland, North Wales, Tortworth, and the Mendips, the horizon has not been found, and may either have never existed or have been removed by erosion. In parts of Pembrokeshire (Marloes Bay, etc.) we have a conformable transition from Upper Ludlow into Old Red Sandstone, which has up till the present defied all attempts at division. It is, however, noted [1] that at the time that this area was surveyed the results of more detailed zoning in Shropshire were not available.

In Scotland a similar horizon in the Pentland Hills shows the same transition from Upper Ludlow to Downtonian forms ; though of course actual identity of horizon is not necessarily implied. In the Lesmahagow inlier all the fossiliferous beds above the "(?) Wenlock" are strictly comparable with the Downtonian both of England and of the Pentland Hills ; but as there is yet no convincing palaeontological evidence regarding the age of the underlying beds we can say only that here beds of pre-Downtonian age are succeeded within a short distance by Downtonian beds. In Kincardineshire there is an unconformity at the base of the Old Red Sandstone (Downtonian). In the case of Southern Scotland also, the information at present available was all obtained before the Ludlow sequence had been worked out in detail by G. L. Elles and I. L. Slater.

The position with regard to the top of the Downtonian is not so satisfactory. In the Welsh Borderland the junction between the Downtonian and the Dittonian is definite enough for practical purposes. In Scotland, however, there is unconformity in the Pentlands, and a strong development of conglomerate at two horizons in Lanarkshire. It is therefore unlikely that the horizon chosen is the same in each case or that either of them is exactly the equivalent of the base of the Dittonian in England In Kincardineshire the divisional line is quite empirical. In Norway [2] the Downtonian sedimentaries are succeeded by a volcanic series. In the Ardennes and at Liévin the change from calcareous marine to deltaic conditions takes place at the top of the Downtonian, with the appearance of a Dittonian fauna.

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[1] Cantrill, T. C., in "The Country around Milford" (*Mem. Geol. Surv.*), 1916, p. 59.

[2] Kiaer, J., op. cit., p. 6.

(2) *Superficial extension.*—The minimum area covered by both horizons as defined above extends from the Malverns to the borders of the Llandilo area, and from Cardiff to the Long Mountain and Wenlock (Fig. 3). They can therefore reasonably be considered as a standard for comparison with other regions.

The area of these rocks exposed in Scotland is so small that it is impossible to accept general conclusions from it without rigorous comparison with the much larger area in the Welsh Borderland. Indeed, the Siluro-Devonian rocks crop out along a total distance of approximately 150 miles in the Welsh Borderland as compared with some 25 miles in the Oslo district and about 40 miles in Bohemia (Fig. 2). The Lower Gedinnian also is inferior both in development and extent, besides having an unconformity at its base. The Welsh Borderland is thus by far the most important outcrop in Western Europe, and this practically eliminates the contention that it should be discounted because it does not give a continuous calcareous marine succession.

(3) *Continuity of Deposition.*—The necessity of continuous deposition, resulting in uninterrupted stratigraphical sequence, is obvious, in that an unconformity implies lapse of time during which deposition was taking place elsewhere. Hence any divisional line drawn at an unconformity is provisional, and must give place to the evidence from an area in which deposition was continuous; so that the finally acceptable divisional plane between two systems cannot be an unconformity. The Scottish succession is a case in point, for the difference between the fish faunas of the Downtonian and the Caledonian loses its force when we consider the difference in physiographical conditions between the two formations. Recent work in Shropshire suggests that where there is less contrast in conditions there is a greater common fauna. Thus only one genus (*Theolodus*) was found to be common to the Downtonian and Caledonian in Scotland, whilst in Shropshire "common to both the Downtonian and Dittonian are *Cephalaspis pagei* [*Thelodus scoticus*], *Parexus incurvus*, *Phlyctaenaspis anglica*, *Psammosteus anglicus*, *Pterygotus*, and provisionally *Macropetalichthys* sp. nov."[1]

Physiographical changes are not of *positive* but of *negative* value in the delimitation of the main evolutionary stages such as the geological systems. A variation in physiographical conditions is a hindrance to the investigation of the developmental life-sequence that must exist between any system and the following one. Without a knowledge of this transitional fauna we cannot establish correlation in the widest sense. We must therefore bear clearly in mind the limitations in this respect that the Ludlow Bone Bed horizon imposes upon us; distinction being made between cases in which the Bone Bed has originally been present, and those in which it has never existed. In all the central portion of the Welsh Borderland, at Marloes and Wooltack Bays (Pembrokeshire), at Usk, Cardiff, and in Southern Scotland we have continuity of deposition. In the Lake District, Llangollen, Freshwater East and West (Pembrokeshire), Tortworth, Gower, and the Mendips, we have Upper Ludlow rocks more or less definitely present. In some of these latter cases we can allow the possibility that the Bone Bed had been deposited originally; but indirect evidence from May Hill and Purton Passage suggests that, in the cases of Tortworth and the Mendips, it may never have existed. At May Hill and Woolhope we have indications of the proximity of a shore-line on the south; but apparently nothing more than penecontemporaneous local erosion of the top of the Upper Ludlow, for at Woolhope the *Delthyris elevata* bed is found below the Bone Bed.

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[1] King, W. W., op. cit., p. 387.

In the case of the Llandilo area there was an actual shore-line in close proximity during Upper Ludlow and early Downtonian times, so that the presumed horizon of the Ludlow Bone Bed (namely, the top of the Grammysia Bed) cannot be present farther west, where the Green Beds form the base of the Old Red Sandstone. A recent interpretation of the Llandilo succession by L. D. Stamp appears to be due to a misunderstanding of the account given by T. C. Cantrill and H. H. Thomas. Near Cilmaenllwyd Quarry the Grammysia Bed is well exposed and contains an abundant typical Upper Ludlow fauna, with the addition of *Grammysia* and *Platyschisma helicites*. It is overlain, apparently conformably, by the pebbly quartzitic grits of the Trichrûg Beds. Upwards the Trichrûg Beds become more argillaceous and pass into red mudstone. They are succeeded by the Tilestones, which, in their turn, give place upwards to the Red Marl division of the Old Red Sandstone. Westward the beds from the top of the Grammysia Bed downwards are gradually overstepped by the higher beds, which themselves thin and die out against the bank of older rocks. The Grammysia Bed is overstepped first, not being seen west of Storm Hill. T. C. Cantrill suggests that it may pass laterally into mudstones similar to those below it before being cut out, but that is a point of minor importance, as it occupies the position at which the unconformity first appears. The Grammysia Bed certainly does not extend as far as to where the Trichrûg Beds and the Tilestones are obviously overstepping the lower beds. Next, the Trichrûg and Tilestone groups thin out to nothing, overstepping onto lower beds of the Ludlow as they do so, until at the smithy on the road half a mile south of Llanfihangel-Aberbythych, Lower Ludlow beds yielding *Monograptus colonus*[1] lie 50 to 100 feet below the plane of unconformity. As noted by H. H. Thomas, the green sandstones and marls that form the base of the Old Red Sandstone west of where the Tilestones die out are to be seen above the Tilestones in the Cennen valley; so that there is no possibility of the Green Beds and the Tilestones being at the same horizon. Indeed, for at least the first mile or two westward from where the Green Beds appear in force, they are seen in the field to be the inshore equivalents of higher and higher beds in the Red Marl division.

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[1] Identified by Mr. J. Pringle.

With reference to the top of the Downtonian in relation to continuity of deposition, we cannot feel on safe ground in any of the Scottish districts, and it has already been pointed out that the Dittonian coast was probably very near the Clee Hills area. Our information on this subject is very poor in South Wales, and may remain so for a good many years to come. Thus, though the information available favours the idea of continuity, it would be unwise to stress it.

(4) *Changes in fauna.*—The faunal changes that take place at the horizon of the Ludlow Bone Bed are very significant. Of these the sudden appearance of fish in great numbers is the most remarkable; but it has been over-emphasized. The specimen of *Cyathaspis* (*Scaphaspis*) *ludensis* found by J. E. Lee in the Lower Ludlow of Church Hill, Leintwardine, is exhibited in the Museum of Practical Geology, along with other specimens from the same locality. Fish-remains are recorded from the Upper Ludlow at Patton in Corvedale,[1] at Dean Brook near Willey,[2] and at Hales End near Malvern.[3] At Little Missenden (Bucks) several fish-bands occur in beds with a typical Upper Ludlow fauna.[4] Further research is certain to add to these, so that we must not make too much of the fish-remains of the Ludlow Bone Bed. Nevertheless, they are sufficiently abundant to justify us in taking the bed as the base of the Old Red Sandstone "age of fishes".

The behaviour of the hinged brachiopod fauna is another significant factor. Throughout Britain the Upper Ludlow assemblage is distinctive. At or close to the Ludlow Bone Bed horizon it disappears almost entirely and does not reappear at higher horizons. In this connection too much stress should not be laid on the succession in an in-shore area like that at Llandilo. Nevertheless, the remarkable abundance of *Grammysia* and the presence of *Platyschisma helicites* in the Grammysia Bed have masked the fact that its fauna is that of the Upper Ludlow. Also, at an appropriate distance below it, we have the *M. colonus* beds of the Lower Ludlow. The reputed fauna of the Tilestones is another misleading factor. Owing to too confident correlation in the past it is impossible to accept most of the older accounts. Hence the actual recorded fauna is only that contained in T. C. Cantrill's account,[1] viz. :—

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[1] Robertson, T., "Summary of Progress" for 1926 (*Mem. Geol. Surv.*), 1927, p. 93.

[2] Ibid., p. 85.

[3] Phillips, J., *Mem. Geol. Surv.*, vol. ii, pt. i, p. 98.

[4] Pringle, J., in "Summary of Progress" for 1915 (*Mem. Geol. Surv.*), 1916, p. 44.

Anodontopsis bulla M'Coy
,, sp.
Ctenodonta sp.
Cucullella antiqua (J. de C. Sow.)
Goniophora cymbaeformis (J. de C. Sow.)
Lunulicardium sp.
Lyrodesma sp.
Modiolopsis sp.
Pterinea sp.
Bellerophon trilobatus J. de C. Sow.
Holopella gregaria (J. de C. Sow.)
Platyschisma helicites (J. de C. Sow.)
Cyrtoceras sp.

This is certainly not a convincing Upper Ludlow marine assemblage.

Another point of great importance is the generally observed principle that a new fauna appears somewhat suddenly and evolves rapidly, whilst a decadent fauna evolves slowly and dies out very gradually. The obviously new fauna in the Downtonian is the fishes; whilst the lamellibranchs, crustaceans and merostomata are comparatively stable as far as our knowledge goes at present. The appearance or disappearance of individual forms at any horizon is of negative significance. Both in Scotland and in England it has always been the continuance upwards of the Silurian fauna that has influenced the question; but palaeontologically this appears to be unsound. In zonal work the indefiniteness of an old fauna must give place to the greater precision of a new fauna. An example that has some bearing on the present question is that of the graptolites. The expiring graptolitic fauna is found to lack the definition desirable for zoning purposes in contrast to the rapidly evolving graptolite forms of earlier periods. In Bohemia, for example,[2] the survival of the graptolites beyond the time of appearance of the first fishes is not a point of real significance in the problem under discussion.

Ceratiocaris and other crustaceans appear in force at the Bone Bed horizon; but they and the lamellibranchs and *Lingula* recur so often both above and below it, wherever the requisite physical conditions appear, that their presence is in no way distinctive. Indeed, the organic remains characteristically associated with the Downtonian fish have at the present time no evolutional significance, but only a physiographical one; and nearly all the genera have a wide range in time both above and below the Downtonian. Nevertheless, should future research establish, in any other faunal group, a developmental succession that can be applied to the rocks in question, we must give due weight to its conclusions.

It is in this aspect of the question that the preferability of the Ludlow Bone Bed to the top of the Downtonian is most apparent. The latter is singularly poor in palaeontological contrasts, and indeed there are few fossils to go upon altogether. As pointed out above it is a question of the evolution of the fishes, and where there is least evidence of unconformity there is least contrast in fauna. The discovery of a few individuals of the *Pteraspis* or *Cephalaspis lyelli* type in the Downtonian is quite possible, and would counter-balance almost all the evidence of contrast; though the presumption at present is that these types appeared relatively suddenly as newly evolved forms at a fairly distinct horizon. Nevertheless it is well to remember that the main faunal distinction between the groups is negative, and is certainly not heavy enough to weigh in the decision that we are trying to make.

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[1] "The Country around Ammanford" (*Mem. Geol. Surv.*), 1907, p. 52. To these may be added *Tentaculites*, found during a recent visit. There are poorly preserved brachiopods in the Sawdde river section. Additional fossil evidence in this district is very desirable.

[2] Perner, J., and O. Kodym, op. cit., pp. 67–72.

(5) *Correlation of different facies.*—With reference to the correlation between calcareous marine and deltaic facies: in this country we are, up to the present, only called on to deal with the Old Red Sandstone. To this the Ludlow Bone Bed is considered to be a satisfactory base. If, however, comparison is not instituted with a contemporaneous succession that is wholly of calcareous marine type, the generality of the conclusion is invalidated. Conversely, a succession wholly calcareous marine cannot be expected to show very sudden changes in fauna; so that a horizon based on uninterrupted marine deposits is frequently lacking in definiteness, and requires comparison with deltaic or partially estuarine series to give it precision. This can now be done, since in the north of France (Liévin) we find a calcareous marine assemblage, mainly of Upper Ludlow type, followed within a short distance by an assemblage that is mainly Devonian in type. This eliminates the chance that a Silurian fauna could have occupied the marine region for any appreciable length of time after the introduction of Old Red Sandstone conditions in Britain. We also know that, after the change from a Silurian to a Devonian fauna in the marine area, there was no long-standing continuance of a typical Silurian fauna in the Old Red Sandstone region, apart from forms of physiographical as distinct from evolutionary significance, e.g., *Lingulae* and *entomostraca*.

The faunal change does not in every case take place entirely at a definite horizon. The selection of a horizon is a matter of convenience, and the greater definiteness of the change at places where marine conditions are giving place to deltaic makes the selection easier in England.

CONCLUSION.

There are thus the following points in favour of taking the Ludlow Bone Bed as the base of the Devonian in the Welsh Borderland. They are arranged in order of increasing importance:—

(1) It is approximately Murchison's original upper limit to the Silurian; (2) its position can be located with much greater ease and accuracy than any other possible horizon; (3) it is the nearest definite and persistent horizon to the line laid down during the

original survey ; (4) its selection eliminates the inherently indefinite idea of "passage-beds" in a question avowedly taxonomic ; (5) it indicates a strongly marked change in fauna without stratigraphical discontinuity ; (6) it lends itself more easily to correlation with other regions than any other horizon that has been suggested.

Correlation with other areas in Europe and North America has been sufficiently investigated in the papers already cited to assure us that our conclusion is a safe one in the present state of our knowledge.

Note.—Since the above was written, certain conclusions by S. H. Straw regarding the base of the Devonian in South Wales have appeared in the GEOLOGICAL MAGAZINE for June, 1928. They can only be profitably discussed in the light of his evidence, when published, but it may not be premature to note one or two points.

(1) The occurrence of *Monograptus leintwardinensis* in the *Grammysia*-Trichrûg beds is not, on the view taken in this article, a conclusive argument against an Upper Ludlow or even a Downtonian age.

(2) *M. leintwardinensis* has already been found so closely associated with Upper Ludlow forms that its existence in the Upper Ludlow seems almost a foregone conclusion. In this connection see *Q.J.G.S.*, vol. lvi, 1900, p. 428, footnote. Recent work at Wenlock confirms this association of *M. leintwardinensis* with typical Upper Ludlow forms in beds that would naturally be taken as the base of the Upper Ludlow. Conclusive field evidence of overstep is therefore the only basis upon which unconformity between the Tilestones and the *Grammysia*-Trichrûg beds can be accepted.

(3) If the unconformity at Llandilo lay between the Tilestones and the Trichrûg beds, the latter would disappear westwards before the *Grammysia* bed, but the opposite is the case.

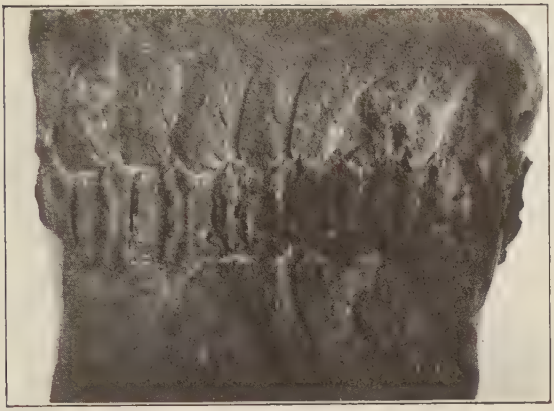
Notes on Myriapoda : XXXII.

AN IMPORTANT SPECIMEN OF *EUPHOBERIA FEROX* FROM THE MIDDLE COAL MEASURES OF CRAWCROOK.

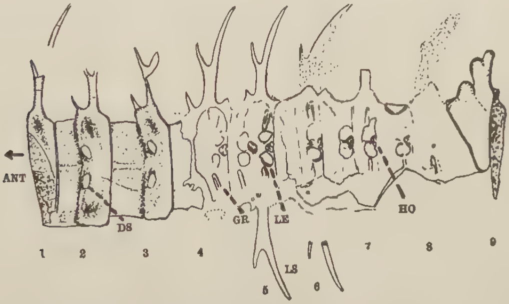
By the Rev. S. GRAHAM BRADE-BIRKS, M.Sc. (Manc.), D.Sc. (Lond.), F.Z.S., Lecturer in Zoology and Geology, S.E. Agricultural College (University of London), Wye, Kent.

(PLATE XVI.)

THE name of no English fossil millipede is more familiar than that which occurs in the title of this paper. At some later date specimens we now refer to this species may be renamed, but as we understand it to-day it is represented by a great array of material from the Coal Measures. In its general body form *Euphoberia ferox* (Salter, 1863) is quite clearly a spined millipede. Its trunk is built up, as is that of living millipedes, of a large number of similar double segments in which each dorsal plate covers two complete



Euphoberia ferox (Salter, 1863). Middle Coal Measures, Crawcrook, about one-and-a-half times natural size. Photograph by J. Wilfrid Jackson, M.Sc., F.G.S. The length of the preserved portion of the fossil, measured along the mid-dorsal line, is 4·1 cm.



A drawing of the specimen illustrated above. Anteriormost segments on the left. *Ant.* (and arrow), anterior end and direction; the figures 1–9 are placed approximately opposite the middle of each of the diplosegments; *DS*, base of one of the dorsal spines, placed near the anterior border of the metazonite; *GR*, groove regarded by the author of the paper as a respiratory opening; *LS*, bifid lateral spine; *LE*, insertion of limb element, there is a corresponding pit on the other side of the middle line of the body: *HO*, heart-shaped area (note similar area in segment 4, an enlarged view being given in Text-fig. 1). About one-and-a-half times natural size. S. G. B.-B. del.

sets of ventral structures including two pairs of legs. The general form of the dorsal surface is very reminiscent of such a recent genus of millipede as *Polydesmus*: in the case of each individual dorsal plate there is the anterior more depressed portion known as the prozonite and behind it is the wider and more elevated portion or metazonite. It is the metazonite which bears the two rows of spines that are found on each side of the body in *Euphoberia*. In *Euphoberia ferox* the spines of the lateral row are better known and more usually preserved than those of the sub-dorsal row. These lateral spines arise from the sides of the metazonites and help to give the body a flattened appearance. Each spine has two spinules at its base, one in front and one behind. The main spine has a large forwardly directed branch. The spines of the dorsal row are simple. The head and tail are imperfectly known and for the purpose of the present paper there is no need to say any more about them.

In a large number of specimens it is natural that by virtue of special conditions of fossilization some should exhibit features not commonly seen and it is to such a specimen that I now wish to direct attention.

In a portion of a clay ironstone nodule collected by Mr. W Eltringham from the Middle Coal Measures (Crow Coal) of Crawcrook near Ryton-on-Tyne is a specimen to which Gill (October, 1924) evidently refers in a footnote (p. 459) as showing " a cross-section of the body and legs ". The specimen exhibits parts of nine consecutive double segments in natural association but in different states of preservation. They are seen from the dorsal aspect only, except where the nodule is broken across at either end of the preserved portion of the body so that an imperfect transverse section is there exposed.

The first three diplosegments.—Beginning at the anterior end of the specimen the first three double segments, as seen from the dorsal aspect, may be considered together. They all exhibit portions of the bifid lateral spines of the right-hand side, which agree in form with those described and figured by Gill (October, 1924) in his account of another specimen from the same place, but none of these three segments is suitably tilted to exhibit the simple lateral spine which Gill (loc. cit.) described and figured as occurring behind the base of the bifid lateral spine in the specimen he studied. Nevertheless, in the case of the second and third segments the position of the simple spine in front of the base of the bifid lateral spine is clearly indicated by pointed impressions, while a slight projection, best seen from an anterior view of the specimen, marks its position in the case of the first segment. Only a small portion of the anteriormost double segment is unbroken, that which lay behind and to the right of the right sub-dorsal spine, the base of which is also broken away. The dorsal surfaces of the second and third double segments are well preserved on the right-hand side of the middle line, but along the left border a fracture of the nodule has carried away a portion of the margin of each segment and every trace of the corresponding lateral spines on that side, and since the figures illustrating this paper were made some injury has occurred to the left-hand side of these segments. Both segments have the typical form with the depressed prozonite and a more elevated metazonite whose anterior ridged margin bears the well-developed bases of the sub-dorsal spines. The front margins of the segments do not, however, exhibit the very blunt point in the median line into which the margins of some of the segments are carried out in the specimen figured by Gill (October, 1924, fig. 1, p. 458), but this may be due, not to the absence of the blunt process, but to its concealment beneath the segment in front.

The fourth diplosegment.—The dorsal surface of the fourth double segment is so much eaten away that no surface feature of importance can be distinguished. On the right, not only is there an impression of the bifid lateral spine, but also of the simple spines which arise both behind and in front of the base of the bifid lateral spine. A slight and indefinite impression, visible on the left probably represents not only the base of the bifid lateral spine, but also the small simple spine behind its base. In the posterior part of the fourth double segment some of the ventral features are seen from within as a result of the loss of the more dorsal portions of that part of the segment. In the median line is a sub-triangular structure, which clearly corresponds to the so-called pair of branchial cups described by Scudder (May, 1882), p. 155, as occurring in *Acantherpestes major* (Meek and Worthen), and figured by Scudder (his pl. ii in op. cit.). The whole structure regarded by Scudder as a pair of branchial cups is exhibited in seven cases in the specimen we are considering, but it is best preserved in the posterior half of this fourth segment. It exhibits considerable differences of elevation and depression and consists of a sub-triangular or heart-shaped area in which the apex is anteriorly directed. An imperfect ridge divides it bilaterally symmetrically, and on either side of this ridge lie two pits imperfectly walled round and separated from one another by a partition. This region has been carefully considered in the light of the opinions regarding features of the ventral plates expressed by Scudder (May, 1882), in the case of *Acantherpestes*, H. Woodward (1887) respecting *Euphoberia*, Fritsch (1899) on *Acantherpestes* and Verhoeff (1926) in his consideration of the same genus, and with some reserve I interpret the imperfect median ridge as the line of separation between the coxae of a pair of limbs and the pits on either side as large openings in the coxae for the exertion and withdrawal of coxal organs. Closely posterior to the feature just considered and in the region belonging to the ventral plate behind it is a triangular elevation which I regard as a cast of the depression which would naturally occur behind one pair of limbs and in front of the insertion of the next pair of slightly anteriorly directed coxae.

On each side of the sub-triangular or heart-shaped area is to be seen a walled pit representing the position of a limb-element. I regard this pit as the base of the telepoditic portion of the limb arising from the outer end of an outwardly and slightly backwardly directed coxa. If my interpretation be correct, the space between the middle line of the body and this large walled pit was occupied by the coxa.

On the outside of the left walled pit is a large oblong-ovate slit running nearly transverse to the long axis of the body but slightly inclined so that its outer extremity is posterior to its inner by about the width of the slit. This slit I regard as a respiratory opening; it appears in the specimen as a groove along the length of whose floor run a small number of striae like the edges of the leaves of a book. These foliations are difficult to distinguish in the best of lights and may be interpreted as consisting of from two to five minute ridges or tiny furrows in the floor of the groove. I consider that the plate bearing this structure is a sternite. A doubtful trace of the corresponding groove on the opposite side of the segment can be made out.

The fifth diplosegment.—Again the greater part of the dorsal surface has gone, so that the more ventral features are exposed. However, the base of the right sub-dorsal spine remains. Its position indicates the degree of lateral displacement which has taken place during fossilization for this right sub-dorsal spine-base lies in a line with mid-ventral features of the trunk. The bifid lateral spines of characteristic form are represented by well-defined impressions on both sides of the body and in each case the anterior simple spine at the base of the lateral spine is represented, while on the right there is a somewhat doubtful impression of the posterior spine as well.

The ventral features exhibited by this double segment are the insertions of elements, in my view telepoditic, of the two pairs of paired appendages with clear impressions of the right posterior groove, which I interpret as spiracle, and some indication of the position of the two similar grooves of the left side. The triangular area containing the pair of so-called " branchial cups " is also clearly exhibited between limb-element insertions which belong to the posterior pair of appendages of this double segment, while some indication of the corresponding sub-triangular area of the anterior portion of this double segment can be made out, from an oblique anterior view, below the base of the right sub-dorsal spine which hides it from the dorsal viewpoint.

The sixth diplosegment.—Although the tergite of this segment has been much eroded, yet not so completely removed as in the case of the last-mentioned double segment, and although there appears to have been a slight deposition of masking material, certain features of interest can be made out. Enough of the impression of the right bifid spine remains to indicate that it was of the same general proportions as those already mentioned, while on the left the nodule is so fractured as to exhibit impressions of the distal elements of the main spine and of its anteriorly directed branch. Anteriorly in this double segment the ventral parts are largely hidden, but its posterior region shows the median sub-triangular area containing the so-called "branchial cups". Imperfectly exposed on the right, but clearly defined on the left are the depressions corresponding to the insertions of the elements of the paired limbs on either side of it. Laterally on the right the groove, oblong-ovate in shape as before, is clearly exhibited and there is a slight trace of the corresponding feature of the left-hand side.

Seventh diplosegment.—The dorsal surface is much eroded and while there has again been a masking deposition of mineral matter, certain ventral features are exhibited.

The bases of the bifid lateral spines are represented by traces and impressions which are somewhat indefinite, that of the right side being more extensive than that of the left. On the left the anterior spine at the base of the bifid lateral spine appears to be represented. Depressions indicate the positions of the insertions of elements of all four limbs and between each pair is the sub-triangular area referred to in the description of former diplosegments. The position of the grooves I call spiracles can be well seen in the case of the posterior part of this double segment and there is a trace of the position occupied by the anterior pair.

The eighth diplosegment.—The dorsal surface has been lost and deposition of mineral matter has occurred, also the impression of the lateral spines is limited to an ill-defined hollow on the right-hand side.

The ventral elements exhibited by this segment include limb-element insertion of the anterior right-hand appendage and the anterior sub-triangular area is also represented by a somewhat ill-defined trace, while there is an indefinite indication of the left anterior oblong-ovate groove and a better outline of the posterior groove of that side. There is a small circular pit in the position of the insertion of limb-element belonging to the posterior left appendage.

The ninth diplosegment has been permineralized and much damaged and shows little of interest beyond the fact that the right lateral spine was evidently comparable in form with those already studied.

The imperfect cross-sections at each end of this specimen which have already been mentioned exhibit a few points of interest. The anterior fracture of the nodule reveals a carinate structure which would appear to be one of the more distal parts, if not the distal element itself, of a limb of the right side, seemingly in its natural position. This element is downwardly and slightly outwardly directed, being articulated at about 115 degrees with a more proximal element which is crushed or hidden and merely represented by a fissure in the clay ironstone surface. In addition there is some slight indication of the sub-cylindrical shape of the body.

The section at the posterior end of the specimen is much mineralized, but serves to give, by comparison with the anterior cross-section, some idea of the sub-cylindrical form of the body and of the dimensions of its cross-section in life; also it confirms our view of the way in which the lateral spines arise from the lateral borders of the metazonites. In the mid-ventral line there is a short sharply-pointed downwardly directed projection of mineral matter,

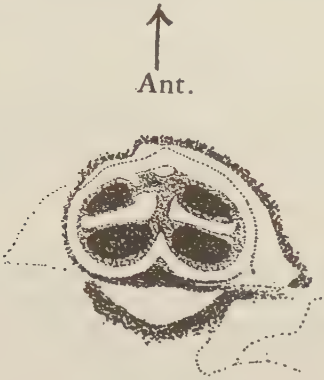


Fig. 1.—The triangular area seen in the posterior part of the fourth diplo-segment. *Ant.* (and arrow), anterior direction. About thirty-five times natural size. S. G. B.-B. del.

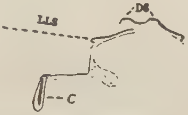


Fig. 2.—The anterior imperfect cross-section. About one-and-a-half times natural size. *DS* the bases of a pair of dorsal spines seen in profile, *LLS* the edge of the plane in which the bifid lateral spines lie (indicated by a dotted line); *C* the distinct carinate structure regarded as one of the distal elements of a limb. S. G. B.-B. del.

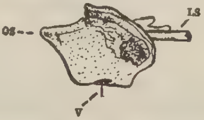


Fig. 3.—The posterior imperfect and permineralized cross-section. About one-and-a-half times natural size. *OS* the point of origin of the left lateral spine; *LS* the permineralized right lateral spine; *V* the ventral projection of mineral matter. The height of the body as represented in this section is 0·6 cm., and its width (below the base of the lateral spines), 0·8 cm. S. G. B.-B. del.

but whether this had any precursor in the living animal it is not possible to determine owing to the permineralized condition of this portion of the fossil.

In a communication to Section C of the British Association at Leeds on 2nd September, 1927, I made brief reference to the specimen I have just described.

I shall postpone discussion of the features exhibited by this fossil and their comparison with the structures seen in other specimens.

I am greatly indebted to Mr. William Eltringham for his loan of the specimen I have described here and to Mr. J. Wilfrid Jackson, M.Sc., F.G.S., for his excellent photograph of the fossil.

There is a plaster-cast of the specimen in the collections of British Museum (Natural History), its registered number being In. 27306; and I have given plaster-casts to the Royal Scottish Museum, Edinburgh (registered as 1928.10), and to the Manchester Museum (registered as LL.131).

SUMMARY.

A detailed description of an important specimen of *Euphoberia ferox* (Salter, 1863) is given. The fossil consists of nine consecutive segments in natural association exhibiting not only dorsal structures but also some of the less-known ventral features.

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On a New Species of *Semionotus* from the Keuper of Nottingham.

By H. H. SWINNERTON.

REFERENCE has been made in previous articles (1, 2)[1] to the discovery of fossil fishes in the sandstone immediately overlying the basal conglomerate of the Keuper near Nottingham. The upper portion of this sandstone splits into slabs two or three inches thick along filmy partings of greenish clay. The specimen described and figured below was found lying upon the surface of one of these slabs with its head partially buried in the sandstone itself. After being carefully cleaned it proved to be a well-preserved specimen of *Semionotus* differing to a sufficiently marked degree from previously described species to merit the creation of a new species.

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[1] Figures in parentheses refer to Bibliography at end of paper.

DESCRIPTION OF THE SPECIMEN.

The specimen is lying on its left side (Fig. 1) and, apart from slight flattening due to pressure, shows very few signs of distortion. The accompanying figure, which is an accurate drawing of the fossil itself, therefore gives a reliable reproduction of the original form of the fish. Its chief measurements are given in the following table.

TABLE OF MEASUREMENTS OF *Semionotus metcalfei*.

	A.	B.
Length from snout to end of lateral line . .	7·8 cms.	100
Length from snout to end of caudal body lobe	8·8 „	112·8
Depth of trunk	3·2 „	41·0
Depth of caudal pedicle	1·2 „	15·4
Length of head with operculum . . .	2·6 „	33·3
Depth of head	2·1 „	26·9

A. Gives the actual measurements.
B. Gives the measurements as percentages of the length.

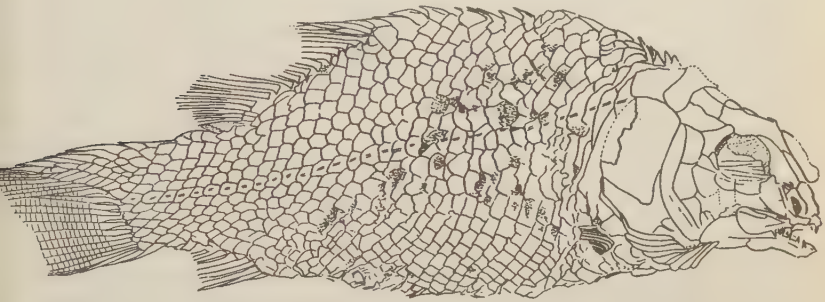

FIG. 1.—Type specimen of *Semionotus metcalfei*. (× 1·2.)

The head as a whole has been slightly distorted by a downward and upward movement of the right and left sides relatively to one another. It is large in proportion to the size of the body and makes up no less than one-third of the length. Whilst its lower boundary is nearly straight, its upper exhibits a marked change of slope above the orbit, being gentle over the cranium and steep over the snout. The orbit is moderately large.

The detailed arrangement of the head bones as far as this was ascertainable, is shown in the figure. Most doubt exists as to the number and boundaries of the circumorbital and other cheek bones. The mouth is small, and is bounded above by well-developed maxilla and premaxilla. The lower jaw is slender in front and deep behind. The teeth are sharp and conical, and are separated from one another by moderately wide spaces. The opercular apparatus is complete and is continued below into a series of at least nine elongated and flattened branchiostegal rays. The praeoperculum is narrow and arcuate, and the mandibular suspensorium is forwardly inclined.

The anterior half of the trunk is deep. Whilst its lower boundary is in approximate continuation with that of the head, the dorsal outline rises rapidly from the roof of the cranium and maintains a high elevation as far as the origin of the dorsal fin. From this point backwards the depth of the trunk diminishes rapidly in a series of constrictions each coextensive with the base of attachment of a median fin. That of the tail region is so great that the body is reduced to a small triangular projection, the caudal body lobe, the apex of which extends half-way towards the tip of the fin. The condition of the tail is therefore abbreviate-heterocercal.

The trunk is completely clad with scales. These are all covered with enamel and are smooth and unornamented with entire margins. There are thirty-three scales in the lateral line and a corresponding number of oblique rows on the trunk and caudal pedicle. Each row in front contains from sixteen to eighteen scales ; those behind have only eleven or twelve. The lateral line scales do not differ from those which adjoin them. There are nineteen ridge scales between the head and point of origin of the dorsal fin, each of which has its point drawn out into a sharp and conspicuous spine. This feature is repeated for the median scales which lie along the dorsal border of the caudal body lobe, and for those near the ventral point of origin of the caudal fin.

The distal portions of the rays in all the median fins are missing, and consequently the outlines of these can only be conjectured. The proximal portions, however, are all well preserved. The dorsal fin greatly exceeds the ventral (anal) fin in size. It is supported by seventeen rays, having their proximal portions undivided and their distal branched. The anterior border is strengthened by several large elongated fin fulcra. The first four or five rays are thinner and more closely crowded than the remainder, whilst the last two or three are much reduced.

The ventral fin is similar to the dorsal but is much smaller and is supported by only six rays. Its base of attachment lies entirely behind that of the dorsal fin.

The caudal fin is supported by eighteen rays of which eleven are inserted below the termination of the lateral line. Seven are inserted above this point and are attached to the lower margin of the body lobe. Beyond the tip of this lobe the fin is bordered dorsally by several greatly elongated fin fulcra. Fin fulcra also occur along the ventral margin. The caudal fin rays, unlike those of the other median fins, do not branch distally, but are flattened and divided into a series of segments each of which has the appearance of a thin enamel clad scale.

The paired fins seem to have been small as compared with the median fins, but their remains are very fragmentary. The pectoral has at least ten slender closely packed rays. Its base of attachment lies distinctly above the ventral line of the trunk and makes a high angle with the body axis. The few traces of pelvic fin that have been found lie opposite the anterior end of the dorsal.

DIAGNOSTIC DESCRIPTION.

The narrow praeoperculum, the absence of an interclavicle, the stout well spaces fin rays, the abbreviate-heterocercal condition of the tail, all indicate protospondylian affinities. The small gape, the forwardly inclined suspensorium, the slightly deepened fusiform body, the relatively short dorsal fin, the large fin fulcra all point to a position among the Semionotidae. The sharp, conical and slightly spaced teeth, the depth of the suborbital region, the large undivided supra-temporal and post-temporal, the strongly arched dorsum armed with spiny ridge scales in front of the dorsal fin, the stout fin rays and large fin fulcra, the shortening in length of the caudal body lobe to half that of the tail fin, characterize this fish as a member of the genus *Semionotus*.

Many species of fossil fishes have at various times been referred to the genus *Semionotus*. A list of these with bibliographic references has been compiled by Smith Woodward (3). Schellwien (4), taking *S. bergeri* (Agassiz) as the type species, has defined the genus more strictly, and reduced its known representatives to the following *S. bergeri* (Agassiz), *S. elongatus* (Fraas), *S. capensis* (Smith Woodward), *S. nilsoni* (Agassis), and *S. kapfii* (Fraas). The specimen described above approximates more closely, in form of body and other characters, to the two species *S. bergeri* and *S. kapfii* than to any of the others. The former species, however, differs from it in exhibiting smaller and much more numerous fin fulcra. Its dorsal, fin is situated in a more posterior position relatively to both the pelvic and ventral fins, and its caudal fin rays are divided into shorter segments. In view of these facts the Nottingham specimen cannot be referred to this species. On the other hand to place it with the species *S. kapfii* is undesirable (5). The original material for this species does not appear to have been adequate for providing a full diagnosis, and defects in either description or figures make detailed comparison with other species impossible. For these reasons it is proposed to call the Nottingham specimen *Semionotus metcalfei.*

NOTE.—Mr. A. T. Metcalfe, F.G.S., co-operated in work upon the Trias of South Notts with the late Mr. Edward Wilson, whose name has already been associated with *Woodthorpea wilsoni* which was found on the same slabs of rock as *Semionotus metcalfei.*

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The Terms "Cast" and "Mould" in Palaeontology.

By John Challinor, M.A., F.G.S.

IN preparing a course of lectures in elementary Palaeontology, the present writer found himself to be vague as to the general terminology of the most elementary part of his subject—the forms of preservation in which fossils occur. To his surprise he found, on referring to the leading text-books, that there was no such general terminology; at least, not in the sense of a terminology in general use.

It was for the meaning of the particular terms "cast" and "mould" that the inquiry was started. All authorities were found to agree that fossils occur commonly as "casts and moulds" and there was no divergence or ambiguity as to the use of this phrase as a whole; but the various forms of "casts and moulds" were nowhere found to be explicitly tabulated and defined (at least not to the writer's satisfaction, with his particular end in view), and the terms used separately were found to have a different meaning with nearly every authority consulted.

A large proportion of Palaeozoic fossils occur only as casts and moulds, and even where the original hard parts are preserved more or less intact, as is the case with the majority of Neozoic (Tertiary) fossils, casts and moulds occur and are important. Thus it seems desirable that there should be some uniformity of terminology in the matter.

In the following suggestions, the term "cast" is taken to imply features represented in positive, "mould" features represented in negative. The definitions are framed for the various forms of preservation when complete, but their usual application would be to forms in various degrees of incompleteness.

INTERNAL MOULD.

The material filling the hollow interior of the shell. The surface of an internal mould shows in negative (i.e. as impressions) the features of the internal surface of the shell, and reproduces in size and shape the form of the hollow interior.

EXTERNAL MOULD.

The material surrounding the exterior of the shell. The surface in contact with the shell (or its cast) shows in negative (i.e. as impressions) the features of the external surface of the shell.

CAST OF THE SHELL.

The material replacing the original shell. It reproduces this shell in size, shape, and surface features.

CAST OF THE EXTERNAL SURFACE OF THE SHELL.

The material replacing the external surface of the original shell. It reproduces the features of this external surface.

As thus concisely defined, it is included in the term "cast of the shell", but it would apply chiefly to the very common form of preservation where the same material has indiscriminately replaced the original shell and filled its hollow interior.

CAST OF THE INTERNAL SURFACE OF THE SHELL.

The material replacing the internal surface of the original shell. It reproduces the features of this internal surface.

As in the analogous case above, the term would be applied usually to the form of preservation where the cast of the shell as a whole is lost. The occurrence of an internal mould implies as a rule the existence of either the internal surface itself or a cast of this surface.

The above definitions and short notes are not meant to include general discussions of facts and principles (such as the character of the rock-material or mineral forming the fossil, the degrees of perfection of preservation, etc.) essential to a proper appreciation of the significance of casts and moulds. These questions are dealt with more or less fully in most of the text-books.

Any individual shell may thus leave three "complete" fossils (and any number of fragments) as its representatives: the external mould, the shell itself or the cast of the shell, and the internal mould; and at least two "complete" fossils are normally left: the cast of the external surface and the external mould, or the cast of the internal surface and the internal mould. Thus, one individual may have more than one labelled (numbered) fossil specimen to represent it (though one may merely repeat the features shown in another, one in "positive" and the other in "negative"); on the other hand a single geological specimen (i.e. a piece of rock bearing, usually, one single label or number) may contain two, or any number of, fossils representing any number of individuals. The above remarks in this paragraph may appear obvious, but in cases where the description of a fauna takes into consideration the numbers of individuals collected and a reference to particular labelled specimens, it is important to avoid chances of ambiguity. Ambiguity is apt to arise by using such familiar terms as "fossil", "specimen", and "individual" either inconsistently or with doubtful meanings.

Finally, it may be suggested that some term is needed to denote what is here referred to by the phrase "the forms of preservation in which fossils occur". This phrase, and others used in the text-books, is unsatisfactory in various ways.

Pipes in the Coast Sandstone of Syria.

By Professor Alfred Ely Day, American University of Beirut.

(PLATES XVII–XIX.)

A CALCAREOUS sandstone is found at intervals along the coast of Palestine and Syria from Gaza to Lattakia, a distance of about 300 miles. It may be a thick deposit, extending for miles along the coast and covering a wide area, as at Beirut, or it may be thin and of small extent. Some parts of the coast are entirely without it. It is the principal building stone of the coast towns. It has been mentioned by various writers. Hull (*Geol. and Geog. of Arabia Petraea, Palestine, etc.*, Pal. Expl. Fund, 1889, p. 9) refers to it as the " Calcareous Sandstone of Philistia ". No geologist, however, has noted the remarkable holes, which in some places penetrate it in great numbers.

These holes are always vertical, from 10 to 20 inches in diameter and from 5 to 15 feet deep, spreading out funnel-like at the surface, and tapering like a cigar at the bottom. The most remarkable features of these are their regularity and the smoothness of their walls. The rock is sometimes rather compact, but is usually of a very spongy texture. The walls of the holes are as smooth as such a texture can admit. The horizontal section approximates closely to a circle. At Beirut, where they are unusually abundant, they are frequently exposed in the quarry scarps, as seen in Plate XVII, Fig. 1, which shows their vertical direction and their size as compared to that of a man. Note the inclined layers of the sandstone, which in the figure are in two unconformable series. Here, as usually, the sandstone is covered with a layer of dark red sand which fills the holes.

Plate XVIII, Fig. 1, shows a quarry in which the superficial sand has been partly removed so as to expose the irregular surface of the sandstone, eaten into pinnacles by the confluence of adjacent holes. Near the Natural Bridge at the head of the Dog River Valley in Lebanon, the massive Upper Cretaceous limestone is similarly affected, with the difference that the holes in the limestone are far from being circular in section, and their walls, instead of being smooth, are sharply fluted, so that an unhappy climber who might fall into one of the holes would risk being cut to pieces.

The dark red sand, which at Beirut commonly covers the sandstone, is compact and firm, but not consolidated, and is itself covered with a variable, sometimes a great, thickness of shifting dune sand, which is of a light brown colour. In one quarry, Plate XVII, Fig. 2, we find the following layers, from above downward :—

(*a*) Brown dune sand.

(*b*) Firm dark red sand, the upper part of which contains potsherds.

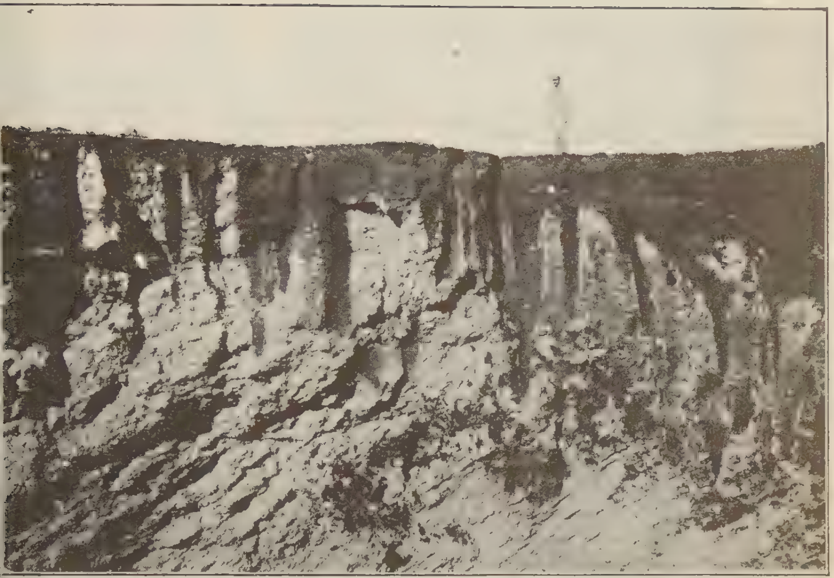


Fig. 1.—Quarry scarp in calcareous sandstone of the Syrian coast, showing vertical holes filled with the overlying red sand.

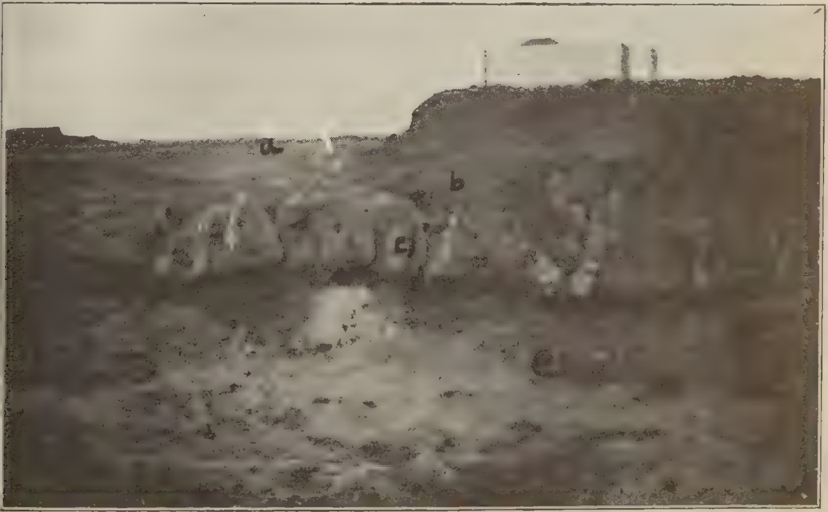
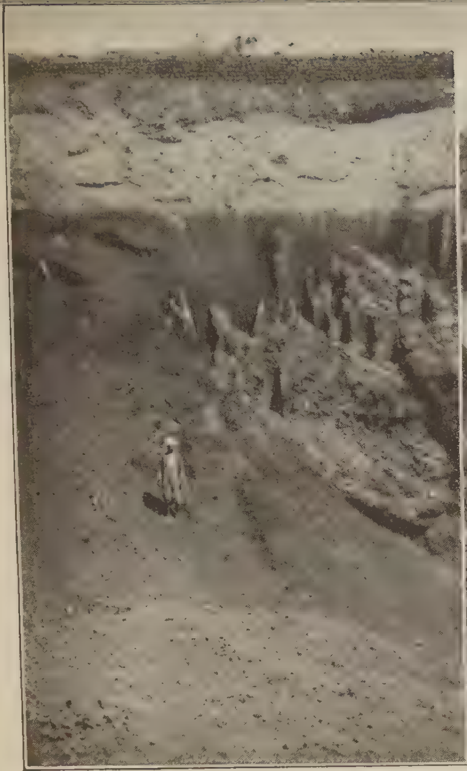


Fig. 2.—*a*, dune sand; *b*, red sand; *c*, sandstone completely perforated with large holes; *d*, second layer of red sand under the sandstone; *e*, sandstone without holes. Quarry at Beirut.

[*To face p. 412.*



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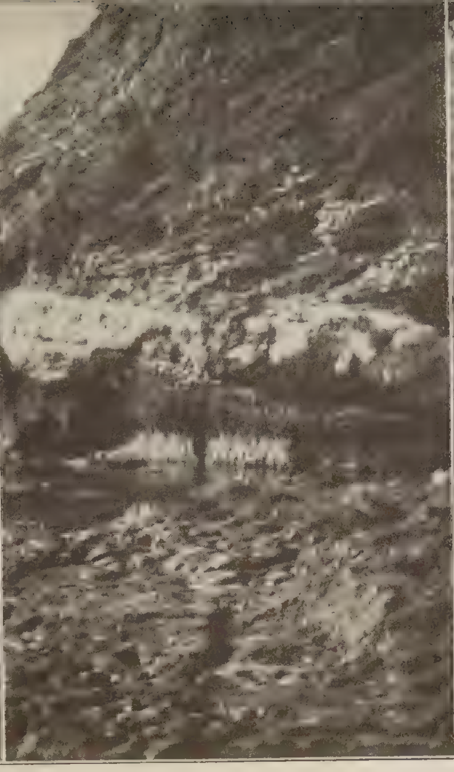

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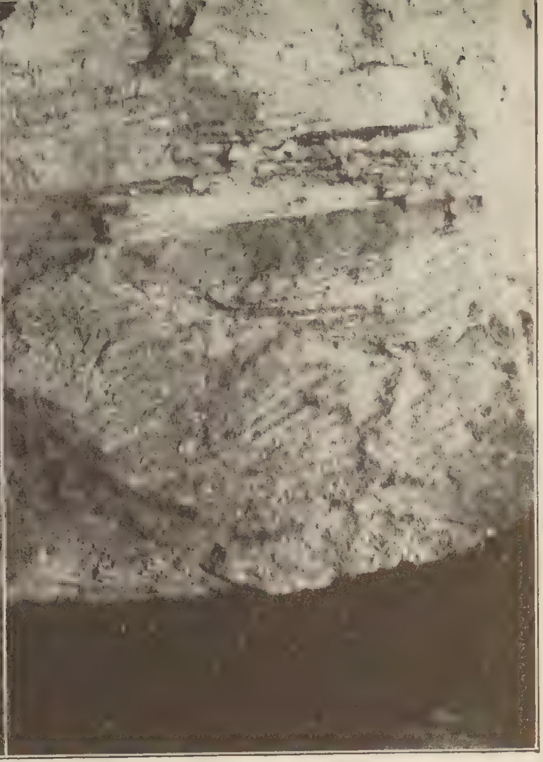

3

FIG. 1.—A QUARRY SCARP WHERE THE SUPERFICIAL SAND HAS BEEN PARTLY REMOVED, SHOWING THE SURFACE EATEN INTO PINNACLES BY THE CONFLUENCE OF ADJACENT HOLES.

FIG. 2.—SEASHORE AT BEIRUT. SANDSTONE RESTING UNCONFORMABLY ON UPPER CRETACEOUS LIMESTONE.

FIG. 3.—IRREGULAR BEDDING IN COAST SANDSTONES.

(*c*) Sandstone, about 6 feet thick, perforated with holes, which here are larger and less regular than usual.

(*d*) A second layer of firm dark red sand.

(*e*) Sandstone without holes.

Note that the holes in (*c*) terminate abruptly, without tapering, at the upper level of (*d*).

Plate XVIII, Fig. 2, is a view at the seashore showing the coast sandstone resting unconformably upon Upper Cretaceous limestone.

Plate XVIII, Fig. 3, shows irregular bedding in the sandstone.

As far as the writer knows, no geologist has mentioned these holes. There is, however, a very interesting and extensive reference to them in an archaeological treatise by M. Ernest Renan (*Mission de Phénicie*, 4to, Paris, Imprimerie Impériale, 1864, p. 193 ff.). In his exploration of the rock cut tombs at Jubayl, the ancient Byblos, about 20 miles north of Beirut, M. Renan came upon one of these holes which led down from the surface into a sepulchral chamber. He concluded that it was artificial and was intended to serve for giving light or air to the subterranean chamber. Finding another hole near by, he laboriously followed it downward, only to find it to taper to a blunt point and end blindly in the rock. Several others were followed with the same result. Still others were found to lead to sepulchral chambers. In one case he found a hole leading to a chamber, and a continuation of the hole in the floor of the chamber. He considers that the holes were made with a large augur or similar instrument, observing at the same time that the diameter of the hole may vary, especially as it widens toward the surface of the ground, and that the axis may bend, producing a slight variation from the vertical. He discusses, and dismisses, the idea that the holes may be natural, and concludes that they were made as soundings before the construction of the tombs. One of his arguments for assuming an artificial origin is that they are found only at places, such as Jubayl and Sidon, where ancient tombs are found. In this he was in error. At Beirut, where there must have been (before the quarrying operations) many thousands of them, they are not associated with tombs. They have been observed at various points along the coast, notably Acre, Sidon, Beirut, Jubayl, and Tripoli. While Renan's conclusion as to their artificial origin is certainly mistaken, his detailed description of them is admirable.

Sir Arthur Smith Woodward, who was taken by the writer to some of the quarries at Beirut where these holes are still to be seen, states that they are comparable to the pipes in the Chalk of the Downs of the south of England. Their resemblance to holes in the limestone of Lebanon was noted above. It seems certain that they are due to the solvent action of water making its way down through the rock. The writer nevertheless finds himself unable to understand how the percolating water could make such smooth, round, and regular holes. Lebanon, like other limestone regions, is full of cavities and passages made by the water, but these are usually very irregular. The nearest approach in Lebanon to these holes in the coast sandstone are the fluted holes near the Natural Bridge referred above.

The coast sandstone seems in most places to be a Quaternary aeolian formation due to the consolidation of dune sand. There is an objection, however, to this view, and that is that the sandstone is much more highly calcareous than the existing dune sand. The dune sand, as may be seen by the appended analyses, has about 4 per cent of lime or 9 per cent of calcium carbonate, and 85 per cent of silica. It consists of worn fragments which average $\frac{1}{40}$ inch in diameter. Most of the grains are transparent quartz, but are somewhat coated with iron oxide. With them are opaque white, yellow and dark grains, some of which are soluble in acid. The soluble grains may be detritus from the limestones or may at least in part be shell fragments. The beach sand has up to $7\frac{1}{2}$ per cent of lime or 15 per cent of calcium carbonate, and its grains are similar to those of the dune sand, but are not coated with iron oxide. The red sand is not calcareous. It has grains similar to those of the dune sand and the beach sand, but mingled with them are many minute angular fragments from $\frac{1}{2,000}$ to $\frac{1}{500}$ of an inch in diameter, all thickly coated with iron oxide. A friable specimen of the Nubian Sandstone from the mountains was found to be very similar in these respects to the red sand.

It is to be noted that the red sand, whether found above or under the sandstone, is never consolidated. In some places, as at Lattakia, the sandstone is clearly a shell breccia, and contains more than 90 per cent of calcium carbonate, but in most places it does not contain recognizable shell fragments, and has a composition similar to samples 1 and 2 noted below. In some places it has embedded in it many shells of *Helix*, which would seem to be a pretty clear indication of its Aeolian origin (Plate XIX, Fig. 1). Plate XIX, Fig. 2, taken on the dunes at Beirut, is a view of what appears to be dune sand partly consolidated. The layers, which are very evident in the figure, are very friable, and are not thoroughly connected together into a solid mass.

PIPES IN THE COAST SANDSTONE OF SYRIA.

Coast Sandstone Sample 1.		*Coast Sandstone Sample* 2.		*Beach Sand.*	
SiO_2	26·88	SiO_2	24·62	SiO_2	81·45
CaO	37·00	CaO	37·37	CaO	7·43
MgO	0·89	MgO	2·30	MgO	00·00
CO_2	31·15	CO_2	30·55	CO_2	7·26
Fe_2O_3	1·14	Fe_2O_3	00·94	Fe_2O_3	2·36
Vol. Mat.	2·04	Vol. Mat.	3·06	Vol. Mat.	1·54
	99·10		98·84		100·04

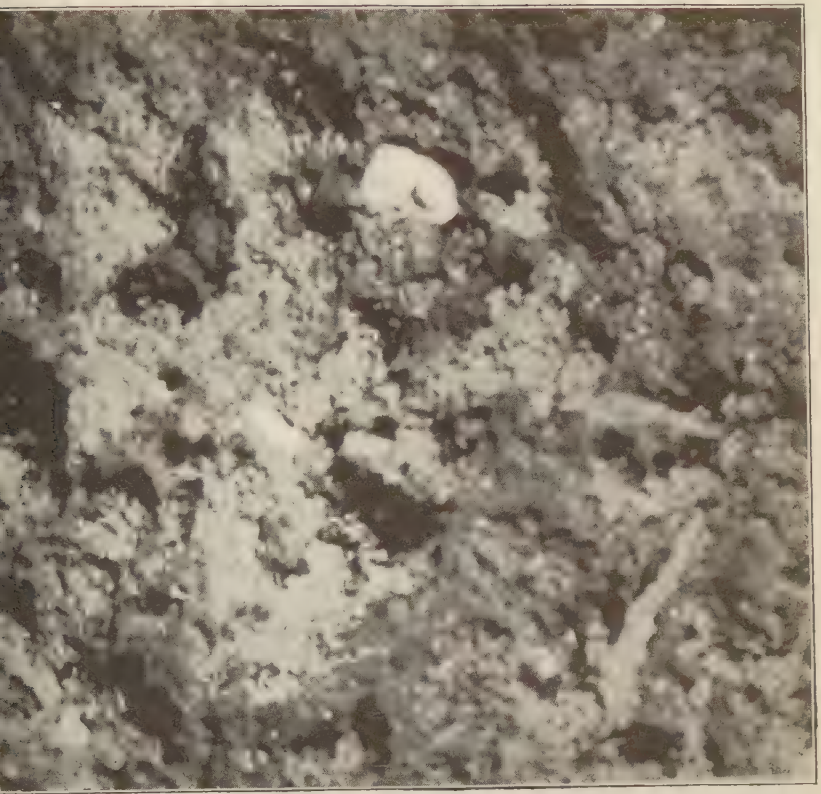

FIG. 1.—SHELLS OF *HELIX* EMBEDDED IN COAST SANDSTONE.

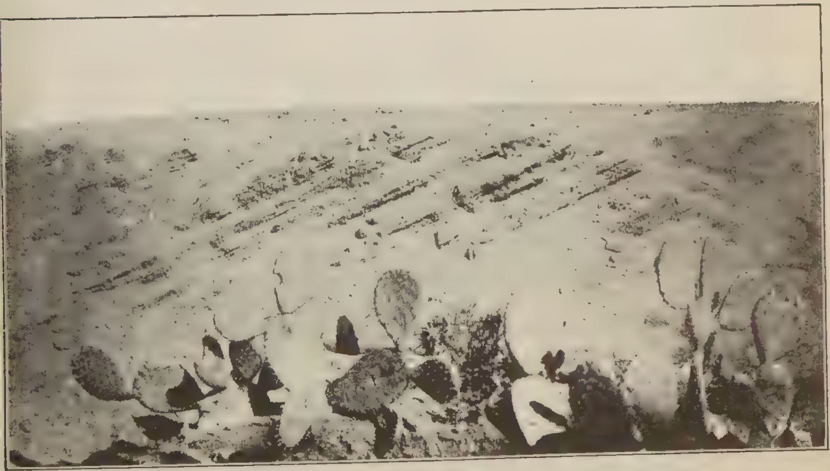

FIG. 2.—PARTIALLY CONSOLIDATED SANDSTONE ON THE DUNES AT BEIRUT.

[To face p. 414.

Brown Dune Sand.	
SiO_2	85·94
CaO	4·15
MgO	00·00
CO_2	4·95
Fe_2O_3	1·18
Vol. Mat.	3·14
	99·36

Red Sand Sample 1.	
SiO_2	93·73
CaO	00·00
MgO	00·00
CO_2	00·00
Fe_2O_3	2·75
Vol. Mat.	3·43
	99·91

Red Sand Sample 2.	
SiO_2	89·35
CaO	00·00
MgO	00·00
CO_2	00·00
Fe_2O_3	6·63
Vol. Mat.	3·97
	99·95

Nubian Sandstone Sample 1.	
SiO_2	95·28
Fe_2O_3	1·67
Vol. Mat.	2·79
	99·74

Nubian Sandstone Sample 2.	
SiO_2	78·75
Fe_2O_3	15·14
Al_2O_3	0·65
Vol. Mat.	3·20
	97·74

Nibian Sandstone Sample 3.	
SiO_2	60·66
Fe_2O_3	33·73
Vol. Mat.	6·28
	100·67

Thanks for the analyses are due to Mr. F. Allahwerdi of the Department of Chemistry of the American University of Beirut.

REVIEWS.

Mineral Deposits. By Waldemar Lindgren. Third edition. pp xx + 1049, with 317 figs. McGraw-Hill Publishing Co., Ltd., London; McGraw-Hill Book Company, Inc., New York. 1928.

AFTER eight years it has again been found necessary to prepare a new revised and enlarged edition of this standard book. The general character of the work is too well known to need any comment here, nor is it worth while to enumerate all the changes made, which naturally involved additions in conformity with recent progress in several directions.

In view of certain recent controversies and discussions on the primary origin of ores, the geologist will naturally look to see whether the author's views have undergone any serious modification, especially as regards the relation of ore-deposit to igneous magmas. Professor Lindgren points out, very wisely, with special reference to the Sudbury sulphides, that much of the trouble arises from a want of precision in the definition of terms, and this is a criticism of very wide application, which it would be well for most writers on the subject to take to heart. Until it is definitely decided what is meant by magmatic and what is meant by hydrothermal, it is not much use discussing whether a given deposit belongs to one or the other category, because as at present understood they are in reality but phases of one continuous process.

The general classification of normal primary ores may perhaps be fairly summarized as: epithermal, mesothermal, hypothermal, pyrometasomatic, and concentrations in molten magmas (omitting all "crank" deposits of exceptional character). It is perhaps notable that the heading "veindike" does not occur in the index, and in nearly every case deposition of vein-material from some kind of more or less dilute solution seems to be accepted. This of course does not necessarily apply to the last category in the foregoing list.

With regard to many of the highly debatable lead-zinc deposits in limestones (Missouri, Moresnet, Pennine area) a somewhat non-committal attitude is maintained. These are undoubtedly difficult to account for on any hypothesis; in the British examples, at any rate, which are not mentioned by Professor Lindgren, the presence of great quantities of fluorite is very unfavourable to any non-magmatic explanation, and even if the ores have been bodily transferred from one situation to another, as has been suggested, the highly insoluble character of this mineral is a stumbling block. This problem must still be regarded as unsolved.

While many of the detailed descriptions of individual instances of ore-deposits in this book are of extraordinary interest and value, it may perhaps be thought that some of the accounts of non-American mining fields of great importance are slightly scrappy. But to describe the whole world on the same scale would require an enormous book, and in most cases abundant references to the literature are given, including many publications up to 1927.

This work will undoubtedly for many years to come maintain its position as the greatest authority on its very difficult but fascinating subject, and it can with every confidence be recommended to students as a well-balanced and temperate statement of the present state of knowledge both on the scientific and economic sides of the vast field that it covers.

R. H. R.

GEOLOGY AND ORE DEPOSITS OF THE LEADVILLE MINING DISTRICT, COLORADO. By S. F. EMMONS, J. D. IRVING, and C. F. LOUGHLIN. Prof. Paper 148, U.S. Geol. Survey, pp. xvi + 368, with 70 plates and 111 figures. Washington, 1927.

THE Leadville district in Colorado may be regarded as classical in the history of mining geology and the study of the genesis of ore-deposits, since it was the scene of the labours of S. F. Emmons, whose monograph on the subject marked an epoch. Although his conclusions have had to be seriously modified, yet they formed the basis of much subsequent and extremely important discussion. Leadville has always been quoted as an example of the close connection that exists between ores and magmas, and in the light of all subsequent work no one can doubt the relation of the great ore-bodies in the limestones of this area to ascending solutions. At a later stage Emmons himself changed his views a good deal, and after his death the continuation of the work fell to J. D. Irving, who died in France in the war: the great task of a re-examination of the data was assigned to G. F. Loughlin, who has carried it to the triumphant conclusion embodied in the great memoir before us.

When reduced to its baldest terms, the geology of Leadville is as follows: on a basement of gneisses and schists cut by a granite batholith of Pre-Cambrian age were laid down a series of sediments, apparently conformable, but in reality with many breaks, dating from Cambrian to Carboniferous, including especially two limestones; the Ordovician "White Limestone" and the "Blue Limestone" mainly Lower Carboniferous, but possibly in part Devonian. Later formations, up to the Cretaceous, were probably once present, but have been removed. In late Cretaceous or early Tertiary times two great series of "porphyries", the White and the Gray, were intruded in sheets and stocks among the older rocks, and these have a dominating influence in the distribution of the ores, the arrangement of the latter being also partly dependent on faulting. The actual mineralization is clearly due to ore-bearing solutions that reacted with the limestones in places when their upward course was checked by impervious rocks above. These solutions were probably derived from the same magma as the porphyry intrusions, though at a later stage of differentiation. It seems to be fashionable at the moment to call this type of solution hydrothermal rather than magmatic, but it is really a distinction without a difference, merely a matter of terminology. The chief difficulty in this case is to determine how these solutions rose through great thicknesses of rock, leaving so little trace of their passage, but there can be little doubt that they did so, and there the question must rest.

R. H. R.

THE GEOLOGY OF MALAYAN ORE-DEPOSITS. By J. B. SCRIVENOR, M.A. (Oxon), F.G.S., Geologist to the Federated Malay States Government and formerly of H.M. Geological Survey of the United Kingdom. Macmillan and Co., London, 1928. Price 16*s*.

IN this book Mr. Scrivenor describes the geological conditions under which tin, gold, and tungsten ores occur in the Malay Peninsula. The area covered embraces the Straits Settlements (Penang, Singapore, the Province Wellesley, the Dindings, and Malacca), the Federated Malay States (Perak, Selangor, Negri Sembilan, and Pahang) and the Unfederated Malay States (Johore, Kedah, Perlis, Kelantan and Trengganu).

Malaya produces annually tin ore yielding over 50,000 tons of metallic tin, more than fifty per cent of which is derived from the small-scale workings of the Chinese. The gold production, amounting to some 14,000 oz. of fine gold, is practically confined to the Federated Malay States. The other ores that occur are those of tungsten, iron, and manganese; but these are at present of no commercial importance.

The geology of the Peninsula is simple in its main features, although certain complications in detail have led to controversy between geologists who have studied Malayan geology. The oldest rocks exposed are the Raub Series of Permo-Carboniferous age, of which the Kinta limestone, some 5,000 feet thick, is the most important element. Overlying the limestone (whether conformably or not has not yet been settled) is the so-called Schist Series, consisting of Triassic shales and quartzites. Both the limestone and the rocks composing the Schist Series have in many areas been subject to intense thermal metamorphism by a granite which was intruded in Post-Rhaetic times. Near the contact the limestone is highly crystalline, and the shales altered to a variety of crystalline schists, among which may be mentioned tourmaline-biotite-schist, biotite-pyroxene-scapolite-schist and quartz-pyroxene-schist. Tin-ore occurs in the granite, in the metamorphosed limestones and schists, and in detritals derived from them.

The granite occurs principally in the so-called Main Range, which apparently is a large bathylith with satellite cupolas and roof pendants. West of the Main Range are two secondary ranges, one of which is the Kledang. Granite also occurs extensively on the eastern side of the peninsula. The sediments are intensely folded in connection with the intrusion of these granite masses, the anticlinal axes running north and south parallel to the main trend of the peninsula.

The occurrence of the tin ore is closely connected with the granite, as may be clearly seen by study of the map that accompanies Mr. Scrivenor's book. The chief tin fields are associated with the Main and Kledang ranges. Between these two ranges, in the limestone and schists of the Kinta valley, 9 miles across at its widest place, in the latitude of Batu Gajah, are some of the largest producers —the Tronoh, Malayan, Penkalen, Lahat, Ipoh, and Beatrice on its western side and the Idris, Gopeng, Ulu Piah, Kramat Pulai, Tekka, and Kinta on its eastern side. Further to the south on the Main Range is the Selangor field, near Kuala Lumpur, in which occurs the Sungei Besi, one of the largest opencast mines in the country. The tin belt on the eastern side of the peninsula is less productive. Its principal workings are those of the Pahang Consolidated Company.

The main production of the Malayan tin deposits is obtained by alluvial methods, that is to say, sluicing, dredging, or mechanical excavation, although the deposits are by no means all of alluvial origin. Deep weathering, such as is common in tropical regions, has so prepared the various formations, that they can be attacked in situ by the methods mentioned. The Tekka clays on the east side of the Kinta valley is a case in point. These are a part of the Schist Series, decomposed by weathering, faulted, brecciated, and disintegrated by collapse over dissolving limestone. This is a common feature in Malaya. Subterranean caves, formed by solution in the limestone, increase in size until the overlying formations collapse into them, forming pockets of soft material admirably suited for mechanical excavation. Another effect of the underground solution of the limestone are the so-called pinnacles, which is the name given to the very irregular floor of limestone uncovered when the overlying deposits are removed in the tin workings.

Lode mining in Malaya is as yet of little importance, as compared to the so-called " alluvial " workings ; but the tin lodes worked by the Pahang Consolidated Company at Sungei Lembing on the Sungei Kenau, are stated by Mr. Scrivenor to be the most productive tin lodes in the world. They have a close resemblance to the Cornish lodes and are described by him as a system of fissure veins on the granite margin, and extending into the granite, but with the values confined to the sedimentary rocks. In the altered sediments tourmaline, chlorite, lithia mica and white mica are abundant. The deepest working at Sungei Lembing is in Willink's mine, the bottom level of which is 1,200 feet below adit. Lodes and pipes have been worked in the western tin belt near Menglembu, at Lahat, and at the Beatrice mine at Selibin. In the latter case the deposit is a pipe in limestone from which between September, 1923, and August, 1926, 3,360 tons of tin were recovered, giving a profit of £230,000.

No doubt as the alluvial workings approach exhaustion, more attention will be directed to lode occurrences ; but no such production can be expected as is at present obtained from the former.

F. H. HATCH.

THE UPPER CRETACEOUS AMMONITES OF NEW ZEALAND. By P. MARSHALL. Trans. New Zealand Institute, vol. lvi, pp. 129–210, pls. xix–xlvii. Issued separately, 1926.

THIS important paper was apparently completed in 1924, and contains no references to literature after 1922. The forty-nine species recorded are carefully described in detail, both the external and the internal suture-lines being figured where possible. A sketch-map is given showing the localities where Upper Cretaceous is known ; they occur along the east coast of both North and South Island, and in North Auckland. The term Batley Series is proposed for the rocks occurring in Kaipara and Whangaroa in North Auckland, where the majority of the specimens were collected ; it is considered to represent " one horizon ", of Upper Santonian or Lower Campanian age.

A. G. B.

THE GEOLOGY OF THE TONGAPORUTU-OHURA SUBDIVISION, TARANAKI DIVISION. By L. I. GRANGE. New Zealand Geol. Surv. Bull. No. 31 (N.S.), 1927. 63 pp. and 7 geological maps.

THIS report deals with the stratigraphy, palaeontology, and economic geology of 1,021 square miles of the Taranaki Province in the North Island of New Zealand. The Tertiary sequence fills the period between the Wanganuian System (Pliocene) and the Oamaruian System (Eocene to Oligocene). The coal-measures are estimated to yield more than 30,000,000 tons of brown coal, and it is suggested that conditions are favourable for the existence of petroleum.

GEOLOGY OF MANGAIA. By P. MARSHALL. Bernice P. Bishop Museum Bull. 36, 1927. 48 pp. and map.

THIS report, the first fruit of a Bishop Museum Fellowship granted for the study of a series of little-known raised coral islands of the Cook Group, is of interest in that the author demonstrates the presence of *Lepidocyclina* at the base of the raised barrier reef. The formation of this particular reef then commenced in the Oligocene or Lower Miocene, and the growth of coral reef has been continuous from the Middle Tertiary to the present day. No indication was found of glacial erosion or postglacial rise of sea-level. The figures and illustrations are not good.

MINERALS AND MINERAL SUBSTANCES OF NEW ZEALAND. By P. G. MORGAN. New Zealand Geol. Surv. Bull. No. 32 (N.S.), 1927. pp. 110 and 2 maps.

THE late Mr. Morgan's final contribution to New Zealand geological literature will be exceedingly valuable to all economic geologists interested in the Dominion. The minerals and mineral substances (coal, clays, building-stones, mineral waters, etc.) are listed in alphabetical order, with localities and references to the pertinent literature in each case. The subject is exhaustively treated with the care and thoroughness which are characteristic of the author's work.

THE TERTIARY MOLLUSCA OF THE CHATHAM ISLANDS, including a Generic Revision of the New Zealand Pectinidae. By J. Marwick. Trans. New Zealand Inst., 58 (4), 1927 (1928). pp. 432–93, pls.

DR. MARWICK here describes some one hundred new species of Middle and Upper Tertiary Mollusca from the Chatham Islands off the east coast of the South Island of New Zealand. A valuable revision of the generic groupings in the family Pectinidae is included. The descriptions are accompanied, as in all Dr. Marwick's work, by excellent line drawings.

THE WEARING OF BEACH GRAVELS. By P. MARSHALL. Trans. New Zealand Inst., 58 (4), 1927 (1928). pp. 507–32.

DR. MARSHALL here describes a series of experiments designed to determine quantitatively the amount of erosion produced on beach gravels by wave action. He distinguishes three actions, viz. abrasion, impact, and grinding. The results, under the mechanical conditions imposed, showed that "impact may produce waste sixteen times as rapidly as abrasion, while grinding acts two and a half times as rapidly as impact".

R. S. ALLAN.

A CATALOGUE OF THE MESOZOIC MAMMALIA IN THE GEOLOGICAL DEPARTMENT OF THE BRITISH MUSEUM. By G. G. SIMPSON. Pp. viii + 216, with twelve plates and 55 text-figures. London: Printed by order of the Trustees of the British Museum, 1928. Price £1 10*s*.

THIS important memoir is the outcome of the work done by Mr. Simpson, of Yale University, as the holder of a National Research Fellowship of the United States of America. Dr. Bather contributes a short preface and this is followed by an introduction by the author and an interesting historical survey of previous work on the subject. Here it is pointed out that the real discovery of Mesozoic mammals was made about 1812, by W. S. Broderip, an Oxford law student, who also attended the lectures of Professor Buckland. The greater part of the memoir consists of an exhaustive account of the morphology and taxonomy of all the various Mesozoic genera arranged in their respective orders, sub-orders, and families, and this is followed by a discussion as to their relationships with one another, and with surviving forms. The conclusions reached are based on much evidence, and are of the greatest interest and importance. It is shown that the other view that the multituberculates were marsupials is no longer tenable. Broom's theory that they are ancestral monotremes, after being carefully considered, is also rejected and the conclusion is reached that they represent an independent specialized group. The triconodonts and symmetrodonts are also separate groups, neither of them having any diagnostic marsupial or placental characters. The pantotheres, on the other hand, display all the characters which would necessarily appear in the common ancestors of marsupials and placentals, and may be regarded as being near the main stem. No ancestors of the monotremes appear in the Mesozoic, and it is probable that this order was independently derived from the reptiles. The later sections of the memoir deal with stratigraphy and the correlation of strata, and it is shown that in the Purbeck and Morrison the mammals are a very important factor in correlation. Finally in order to place the different elements of the same mammalian fauna in the appropriate geological units the species recognized are arranged in a series of faunal lists. There is an admirable index.

F. H. A. M.

ON A SPECIMEN OF ELEPHAS ANTIQUUS FROM UPNOR. By the late C. W. ANDREWS, with further notes on the teeth and skeleton by C. FORSTER COOPER. Pp. viii + 26, with frontispiece, eight plates, and five text-figures. London: Printed by order of the Trustees of the British Museum, 1928. Price 10*s*.

THIS monograph consists of an account of the Upnor elephant, discovered in 1913, and as now mounted the finest and most complete skeleton of *E. antiquus* in existence. Only the skull, the right fore-limb, and the ribs are wanting. The greater part of the skeleton is described by the late Dr. Andrews, whose untimely death prevented him from finishing the work. The account of the remaining parts, comprising the vertebral column, pelvis, and teeth, was entrusted to Mr. Forster Cooper, who has spared no pains in bringing the memoir to a successful completion. The specimen is of great interest as showing a considerable mixture of specific characters. Thus the femur is like that of *E. africanus* while the astragalus resembles those of *E. maximus* and *E. primigenius.* The outstanding features of the Upnor elephant are, however, the unique upright position of the vertebral spines, and small size of the teeth as contrasted with the great bulk of the body. But, as Mr. Cooper remarks, in the absence of confirmatory evidence from other specimens, the facts are at present insufficient to warrant the formation of a sub-species. The memoir is preceeded by an explanatory preface by Dr. Bather.

F. H. A. M.

THEORY OF CONTINENTAL DRIFT: A SYMPOSIUM ON THE ORIGIN AND MOVEMENT OF LAND MASSES. By W. A. J. M. VAN WATERSCHOOT VAN DER GRACHT and others. pp. x + 240, with 29 illustrations. The American Association of Petroleum Geologists, Tulsa, Oklahoma: Thomas Murby & Co., London, 1928.

IN the case of a theory like Wegener's, which cannot be definitely proved or disproved, a symposium such as this is very valuable. No man is free from a bias imposed upon him by his previous limited knowledge and experience, and it is useful to see how the matter appears to men whose experience has been different. Fourteen writers have taken part in this symposium.

The subject is introduced by Van der Gracht, who is a supporter of the theory. Of the 226 pages of text, his introduction occupies 75, and his reply to the discussion takes 30. In addition, there is an article of seven pages by Wegener himself, and accordingly the theory has been well treated in the matter of space. Van der Gracht has evidently made an honest attempt to reach the truth and has tried to present the evidence fairly; but he is not entirely free from the human weakness of thinking that his theory is true unless its opponents can disprove it, and their theories are false if they cannot prove them. He believes the theory of continental drift because it explains so much, although there are difficulties in the way of its acceptance. He disbelieves the contraction theory although it explains so much, because there are difficulties in the way of its acceptance. On the whole, however, his statement of the case is open-minded, and his chief concern is that the idea of continental drift should not be rejected as impossible or absurd. He does not himself agree with Wegener in all respects. He thinks, for instance, that there is much sial on the floor of the Atlantic, and that the present African and South American masses were never directly in contact. There has been a certain amount of intercontinental subsidence as well as drifting. The idea suits the facts better than actual contact ; but what becomes of the structural coincidences between the east and west Atlantic coasts upon the precision of which Wegener bases his calculation that the probability in favour of his views is 1,000,000 to 1 ? Strangely enough, in spite of the intercontinental subsidence, Van der Gracht attaches considerable importance to these supposed coincidences.

Wegener's article is surprising because the first part is so unlike his book. He refers to the Squantum tillite and other deposits in the Carboniferous and Permian of North America which have been described as glacial. He almost allows that if they are glacial his reconstruction of the period must be wrong ; but—here Wegener becomes himself again—he does not admit that they are glacial.

Joly, Gregory and F. B. Taylor are occupied with their own theories rather than with Wegener's. Joly thinks that continental displacement is not improbable during periods of fluid substratum. Gregory allows a certain amount of lateral displacement, but holds that in the main the distribution of continent and ocean has been determined by vertical rather than horizontal movements. Taylor is a whole-hearted supporter of displacements, but his displacements are not those of Wegener. He develops his theory that the great Tertiary mountain ranges are an indirect effect of the capture of the moon, which he supposes to have occurred during the Cretaceous period ; but he does not attempt to explain the mountain-building which took place before that capture. The natural corollary would be that other moons have been captured and lost.

Molengraaff is rather favourably disposed towards the drift theory, but not to the prevalent westerly drift of Wegener. Singewald, like several of the other writers, dislikes Wegener's one-sided statement of the evidence and considers the chapter on geodetic arguments particularly unfortunate. Nevertheless he thinks continental displacement probable, but he disapproves of the extension of the theory to mountain-building.

The remaining writers are distinctly unfavourable. David White, indeed, says little, but he asks very pertinently why the forces tending to separate the sial masses did not begin to act till so late a period. Bailey Willis, Longwell and Bowie base their objections to the theory chiefly on physical grounds, Chamberlin, Schuchert, and Berry chiefly on geological grounds. Incidentally Chamberlin remarks concerning Wegener's hypothesis :—" Its appeal seems to lie in the fact that it plays a game in which there are few restrictive rules, and no sharply drawn code of conduct. So a lot of things go easily." It is very true. With the liberties that Wegener takes, it would be easy to fit the theory to almost any set of facts, real or imaginary ; and Schuchert in particular shows that quite a number of the facts to which Wegener has fitted it are imaginary. Apart from the introduction Schuchert's contribution is much the longest in the book. It is a critical analysis of the geological evidence, and should certainly be read by those who have been disposed to take Wegener's statements at their face value.

Van der Gracht's reply to the discussion is not on the same plane as his introduction. It is largely a piece of special pleading. There is, however, some excuse. His space is limited and he has much to answer.

Taken as a whole the book indicates a sane and open-minded attitude towards a revolutionary theory, and reflects credit upon those who took part in the symposium. Van der Gracht need not fear that any germ of truth there may be in the theory will be lost, but the American geologists will not be misled by a one-sided statement of the evidence.

P. L.

DER WERDEGANG EINER ERUPTIVMASSE. By S. VON BUBNOFF Forts. d. Geol. u. Pal., Band VII, Heft 20, pp. viii + 239, with 6 plates and 31 text-figures. Berlin: Borntraeger, 1928. Price 20 *M.*

THE main object of this book is an attempt to elucidate, by a study of the tectonics and petrology of the Schwarzwald, the principles underlying the relations in space and time of igneous rocks and earth-movements. Refined petrographical methods, largely relating to the characters of the felspars of the igneous rocks, are combined with detailed field-studies. It is only possible here to summarize very briefly the main conclusions, which are that earth-movement, intrusion and differentiation begin contemporaneously, and are reflected in the phases of separation of minerals in the primary magma; they run concurrently and in the same direction, but their effects vary at different levels; hence the resulting phenomena may be overthrusting with tear-faulting, plastic deformation, or pure intrusion. But the author leaves the question open whether the movement of the blocks originates deep-seated differentiation and rise of magma, or whether magmatic flow induces the movement of the blocks. The intensive study of granite-intrusion and its attendant phenomena now proceeding in central Europe is undoubtedly leading to a marked advance in our conceptions of the relations of earth movement and magmatic activity, as well as modifying our ideas as to the form of the underground extensions of intrusions of large surface-area.

R. H. R.

REPORTS AND PROCEEDINGS.

Geologists' Association.

8th June, 1928.

"The Carboniferous Limestone of the North Crop of the South Wales Coalfield." By T. Robertson, B.Sc., Ph.D., and T. Neville George, M.Sc.

The Upper Carboniferous Rocks of the South Wales Coalfield are bordered by a narrow belt of Carboniferous Limestone. On the North Crop this extends from Pontypool on the east to Kidwelly on the west. The overstep of the Millstone Grit known to exist on the South-East Crop increases northwards, until at Blorenge and the outlier of Pen-Cerig-calch, only a portion of the Lower Limestone Shales remains below the Grit. Westwards, successively higher zones appear, until between Penwyllt and Kidwelly, the Upper Limestone Shales (D_2–D_3) generally underlie the Grit.

All the zones of the Limestone attenuate northwards on the East Crop, and this thinning continues westwards along the North Crop in the Z–S_1 Zones. It culminates in the development of an unconformity near Penwyllt, and west of that place the Upper *Seminula* Zone rests upon a variable thickness of the K Zone. This is the unconformity between the Upper and Lower Avonian first detected by Mr. E. E. L. Dixon on the western side of Carmarthen Bay. The higher beds of the Old Red Sandstone appear to thin out or are overstepped westwards, and an unconformity is apparent at the base of the Limestone near Llandebie. This develops westwards into the great overstep of Carboniferous Limestone on to Lower Old Red and Silurian rocks that is found in Western Carmarthenshire and Pembrokeshire.

The beds show a general constancy in lithological and faunal characteristics along the Crop, but a remarkable and abrupt change in the faunal content of the D_2 Zone occurs a few miles east of Kidwelly. This seems to be connected with the presence of a barrier separating two areas of deposition. The facts adduced permit of a reconstruction of the shore-lines during portions of Avonian time, and also materially assist in determining the changes in conditions in the South-Western Province during that period.

"The Alleged Pliocene of Buckinghamshire and Hertfordshire." By R. L. Sherlock, D.Sc., A.R.C.S., F.G.S.

In this paper the author replies to Dr. S. W. Wooldridge's paper on the Pliocene History of the London Basin in so far as Buckinghamshire and Hertfordshire are concerned, and concludes that a case for the Pliocene age of deposits in these counties has not been made out. He maintains the attitude of his previous paper on the Superficial Deposits of South Herts and South Bucks (*Proc. Geol.*

Assoc., vol. xxxv, 1924) that the age of the deposits is uncertain, but the balance of evidence is in favour of them being in part Eocene deposits modified by glacial action, and in part of Pleistocene age.

The Devil's Dyke, near Brighton, is regarded as similar to the channels at Ivinghoe, Luton, etc., in the Chiltern Hills (*op. cit.*), which involves the presence of ice in the South Downs during the Glacial period.

GEOLOGISTS' ASSOCIATION.

6th July, 1928.

F. Gossling: "The Geology of the County Around Reigate." (Weald Research Committee Communication.)

The district described extends from Brockham to Redhill and Merstham, and lies between the outcrop of the Lower Chalk and the base of the Atherfield Clay.

The tectonic features comprise a number of minor anticlines, monoclines and domes imposed upon the small portion of the northern limb of the Wealden dome upon which the district lies, and a strike fault of considerable throw, as well as the dip faults already recorded. These features are portrayed in one conspectus by means of a sub- and super-surface contour map representing a selected stratigraphical horizon.

For the details of the stratigraphical succession and its lateral variations, lithological characters have perforce been relied upon, in the absence of palaeontological data, and a liberal use has been made of mechanical analysis in the study of the Lower Greensand sediments. By this method of examination it has been possible, while provisionally retaining the usual main divisions of the Lower Greensand, to subdivide and correlate these apparently very variable sediments according to a scheme which is applicable to the whole district.

This scheme discloses four minor cycles of sedimentation between the Weald Clay and the Lower Chalk. Among the more striking results arrived at are:—(1) the persistence of characteristic pebble beds at the top of the Hythe series and at the bottom of the Folkestone series; (2) the tracing of the Sandgate Beds across the whole district; and (3) the manner in which the thick Nutfield Stone and Fuller's Earth beds are developed as a definite stratigraphical horizon by lateral changes and thickenings from a normal, relatively thin Sandgate series.

The Folkestone series is distinguished by a remarkable clay band which divides the upper pebbly sands from the massive silver sands below, and the latter indicate the near neighbourhood of dune-sand conditions. In the Gault a zonal classification has been effected across the outcrop at Merstham.

H. A. Hayward: "The Geology of the Lower Greensand around Dorking, Surrey." (Weald Research Committee Communication.)

The district extends westwards from the area described in the previous paper as far as a north-south line running from Abinger Hammer to Holmbury Hill. It possesses some of the most elevated tracts, including the highest point, attained by the Lower Greensand in the Weald, and is remarkable for the sudden widening of the outcrop from barely half a mile in the east to upwards of 3½ miles in the middle and western portions of the district and for the striking scenic effects resulting from this variation of width of outcrop.

Several investigators have described the district principally from a lithological point of view, but no published map of precision is known later than one by Lucas in 1880, which is practically a copy of the one-inch map of the Geological Survey published in 1862. The paper establishes features connected with the petrology, correlation, and tectonics which have not yet received previous mention.

MINERALOGICAL SOCIETY.

12*th June*, 1928.

Professor F. Slavík and Dr. L. J. Spencer: "Place-names of mineral-localities in Central Europe."

Many important mining districts in the former Austro-Hungarian monarchy are now in other countries and the localities are now known officially by other names. Lists are given for each country and province with equivalent place-names in the various languages (fifteen in all), together with a statement of the principal minerals from each locality. A key to the pronunciation of letters with diacritical marks and a glossary of geographical terms that enter into the construction of place-names are added.

Dr. L. J. Spencer: "Eleventh list of new mineral names."

The first list of this series was published in 1897 and gave all the names of minerals not in the sixth edition of Dana's *System of Mineralogy* (1892). Others have appeared every three years at the end of each volume of the *Mineralogical Magazine.* They are intended as dictionary lists of new names rather than lists of new minerals. About 170 names are now added.

Mr. A. F. Hallimond: "On the atomic volume relations in certain isomorphous series; III."

In the preceding parts of the paper it was shown that the volume-differences in isomorphous series derived from the same group of eutropic elements stood in a constant ratio in all series, and that this relation could be used to calculate atomic volumes for the elements in the combined state. It is now shown that compressibilities agreeng with those determined by Slater for eleven alkali halides can be calculated from the atomic volumes already assigned to the combined elements, by means of the relations $\beta = V/K$ $\beta' = V'/K'$, where β, V, are the compressibilities and atomic volumes of the combined metals; β', V' those of the halogens. For all the metals K has the value -4×10^{-6}, for the halogens K' is approximately $-2{\cdot}5 \times 10^{-6}$. The compressibilities of the free metals, as well as the atomic volume relations and the compressibilities in the combined state, are shown to be consistent with relations of the type $pv = K$, already indicated by Richards for the free metals; K, the constant for the eutropic group, assuming a new value in each isomorphous salt-series. The atoms thus behave as regions of a perfect gas under a high pressure.

Mr. H. Collingridge: " On the determination of optic axial angles and crystal forms from observations by the Becke method in thin sections."

A suggested method of combining separate observations of different sections in one stereographic diagram and incidentally finding from the combined diagram the forms and axial ratios and optic axial angle of the crystal. The method is illustrated by an example of olivine in an olivine-basalt.

Mr. S. I. Tomkeieff: " A contribution to the petrology of the Whin Sill."

In this paper are described certain rare varieties of the Whin Sill, such as the coarse gabbroidal rock, occuring in the form of bands within the mass of the normal dolerite, the coarse rock with red granophyric spots, the red felsitic veinlets, and spherical aplitic inclusions. A scheme of differentiation is applied to explain the origin of these varieties.

CORRESPONDENCE.

THE ORIGIN OF THE DWYKA DEPOSIT.

SIR,—I may be allowed to reply briefly to Dr. du Toit's remarks which appeared in your issue of May last, in connection with my paper on the origin of the Dwyka " Conglomerate " (vide GEOL. MAG., Vol. LXV, No. 765, III, 1928).

Dr. du Toit doubts whether much, if anything, is to be gained just now through attempting to dispose of my criticisms. He prefers to put them before the tribunal of the next International Geological Congress, " when a concourse of geologists drawn from all parts of the globe " . . . will be conducted " over what is hoped will be admitted by Dr. Sandberg as representative sections of the Dwyka Series ".

The excursions planned (vide second circular) and the choice of their leaders, amply warrant the entire fulfilment of the promise quoted above.

Thus, nobody will doubt that these sections will represent choice specimens of the Dwyka occurrence, both in structure and composition; that they will contain a reasonable percentage of polished, striated, and grooved material and similarly marked substrata. In one word, we may be perfectly confident that these sections will show all the characteristic features of the Dwyka deposit.

It is not, however, the existence of these features in South Africa nor the measure of their development which are in dispute. The only thing which is contentious about them is *their origin*, or, to be more precise, the dispute is restricted to the conflicting modes of interpretation of the available geological documents from which the origin of the deposit may be deduced. The question to be submitted to the judgment and decision of the tribunal is that of the admissibility of the one interpretation as against the other.

Adopting Dr. du Toit's simile of a test case before a High Tribunal, may I be allowed to propose the following mutually binding terms of submission between parties in order to secure an unequivocal judgment on the essential merits of the case at issue ?

1. It shall be agreed upon that the criteria on which the contention of the glacial origin of the Dwyka deposit was established and is being maintained consists of the polishing, striation, and grooving phenomena established on various elements of the deposit and on its substrata.

2. It is furthermore agreed upon that the parties join issue on the interpretation of these phenomena, the one party maintaining that the said phenomena pertain exclusively to a glacial cause, and that consequently the ultimate establishment of their occurrence implies the one conclusion only, namely, that of a glacial origin ; the other party, however, maintaining that the said phenomena equally pertain to other causes, e.g. such as are of volcanic origin and that therefore the criteria on which the contention of the first party is based and, consequently, the conclusions derived therefrom, are inadmissible.

3. As to the other characteristics of the Dwyka deposit, although perhaps, individually, considered of minor importance for the appreciation of the case, it is agreed between parties that similar divergence of opinion as formulated above exists on the question of their origin.

Although a geological question is thus put in a rather unusual judicial form, such construction has the decided advantage of allowing the case to be put with great precision, which is of eminent importance in view of its decisive bearing on some fundamental principles of geological science.

The prospect that the I.G.C. in its session at Pretoria in 1929, on the classical ground of contest over the origin of the Dwyka, will be called upon to render a final judgment is bound to stimulate materially its attractiveness, as, by its verdict, it is destined to secure itself a prominent place in the history of geological science.

If, finally, the correct interpretation of Dr. du Toit's comments should be taken, as it was suggested, as an appeal to my co-operation for a final settlement of the case, then he may be sure that it will be given whole-heartedly and to the full extent of my power. For apart from any other consideration on my part of loyalty between coworkers, which I am sure will be reciprocated, his initiative would have proved conclusively that, of whatever nature the divergencies of our opinions may be now, we are in perfect unison on this important point, namely that it is of no consequence as to *who* is right as long as it shall be decided *which* is right.

C. G. S. Sandberg.

The Hague.
June, 1928.

THE SPECIES PROBLEM.

Sir,—In his criticism of my monograph *The Species Problem* (Oliver and Boyd, 1928) your reviewer states that " it is noteworthy that Mr. Robson should have omitted to refer to Gulick's work published in the Linnean Society's *Journal* (vols. xx and xxiii) over thirty years ago ". May I point out that Gulick's work is cited on pp. 117, 118, 119, 132, 133, 135 (and foll.) of my book? The actual papers mentioned by your critic are not cited, but their substance is contained in Gulick's comprehensive work (*Pubn. Carnegie Inst. Washington,* No. 25, 1905) to which reference is made in my bibliography.

G. C. Robson.

British Museum (Natural History),
Cromwell Road, S.W. 7.

[By omitting to refer to the important papers published by the Rev. John T. Gulick in the Linnean Society's *Journal,* Mr. Robson obscures the fact that the idea of isolation as a fundamental factor in the origin of new species had already been developed by that zoologist in the last century and that Romanes had made it the basis of his well-known views formulated in the third volume of *Darwin and after Darwin.* Mr. Robson gives only two references to Gulick in his bibliography, one to " A. Gulick " (1904) and the other to " T. Gulick " (1905).—The Reviewer.]

THE GEOLOGY OF NIGERIA: SOME CORRECTIONS AND ADDITIONS.

Sir,—Having now completed a second period of service in Nigeria, I should be glad if you would allow me to record briefly in your pages the following corrections of, and additions to, the account of the geology of the northern provinces contained in my *Geology and Geography of Northern Nigeria* (1911, and subsequent publications.

(1) With reference to the two groups of gneisses (*G. and G.*, p. 119), local opinion is hardening towards the hypothesis of the intrusion of various orthogneisses into an earlier series of paragneisses, as advocated by Dr. Parkinson for the southern provinces (*Q.J.G.S.*, xliii, 1907, p. 308).

(2) About forty outcrops of " alkaline granite of the second type " (*G. and G.*, p. 132) have been mapped in connection with the recent survey of the tinfields and described in Bulletins Nos. 1, 4, 5, 9 and 11 of the Geological Survey of Nigeria. The rhyolites and quartz-porphyries associated

with the granites are now known to belong for the most part to a somewhat earlier period of intrusion and not to be simply chilled marginal features. The bulk of them preceded the granite, though minor intrusions also followed. The statement of relationship between the granites and the rhyolites of the Buji Hills, given in Bulletin No. 1, p. 18, requires modification in this respect. Also the quartz-porphyry mentioned in Bulletin No. 1, p. 15, having originally formed part of the roof of the intrusion-chamber is probably invaded by the granite, not vice versa.

(3) The syenites of Bauchi Town (*G. and G.*, p. 135) have been shown to be connected with the older porphyritic gneissose granite (*G.S.N.Bull.* No. 9, p. 41). True syenitic differentiates of the younger granitic magma have however also been described (*G.S.N.Bull.* No. 4, p. 13).

(4) A Lower Cretaceous fossil, described by Dr. Spath (*G.S.N.Bull.* No. 12, p. 53), indicates the occurrence of rocks of a greater age in the Benue valley than originally anticipated. In the Gongola valley (*G. and G.*, p. 160), Cretaceous shales have been found near Fika and in a borehole farther north at Damagam, 20 miles east of Potiskum.

(5) The discovery of bonebeds in the north-west of the Protectorate *G.S.N. Occ. Paper* No. 2) has raised the question of the exact age of the Sokoto Series. I fear I was under a misapprehension when I reported the occurrence of Nummulitic limestone in this part of the country (*G. and G.*, p. 167). My own further inquiries have not resulted in any confirmation of the statement.

(6) The material described as "surface ironstone" (*G. and G.*, p. 199) is now commonly, though loosely, spoken of as laterite. Where it forms a crust on rocks decomposed in situ it marks the occurrence of primary lateritic weathering. Elsewhere it is a secondary laterite of varied origin.

(7) The red earthy drift of the Bauchi Plateau (*G. and G.*, p. 203) has been closely investigated and is now generally known as the Fluvio-Volcanic Series. The separation of an earlier from a later volcanic series in *G.S.N. Bull.* No. 1, p. 11) is, however, of doubtful application to the whole area. It is possible that there may have been only one extended period of volcanic activity.

J. D. FALCONER.

LONDON.
June, 1928.

THE MAGMATIC ORIGIN OF ORES.

SIR,—Whilst cordially agreeing for the most part with your interesting paper in the current number of THE GEOLOGICAL MAGAZINE, and especially with your broad interpretation of the term "magmatic", I shall be glad if you will allow me to make a few observations on one point.

The conception of an underlying granite bathylith as the source of the large fluorite deposits of Derbyshire is not easy of acceptance.

It is noteworthy that these deposits are concentrated in the regions of extensive vulcanicity during Lower Carboniferous times, on the eastern margin of the limestone massif, and in the inliers of Crich and Ashover. Further, they appear to be restricted to the uppermost 400 or 500 feet of the limestone, *above* the lava-flows.

It seems clear that large amounts of magmatic emanations, carrying silica and other minerals in solution, have arisen from some underground source, and that source appears to be always associated with the lava-flows and vents, and not with the olivine-dolerite intrusions. The Ember Lane vent at Bonsall; the Ashover vent; the Speedwell vent near Castleton; the Cracknowl vent near Bakewell, all illustrate this point. In the neighbourhood of the first three of these vents there are large replacements of limestone by quartz-rock (as shown by Dr. Bemrose) accompanied by much fluorite. Near the Cracknowl vent there are extensive, contemporaneous beds of massive chert, analogous to geyserite, with fluorite only in small quantity. It seems impossible to doubt that all these deposits have resulted from solutions of magmatic origin.

On the granite-bathylith hypothesis (waiving all difficulties as to location and depth below the surface) it would seem reasonable to expect fluorite to occur throughout the length and breadth and thickness of the limestone massif, instead of being restricted as shown above.

It seems possible that an explanation may be found in the chemical composition of the lavas themselves. Although essentially basaltic throughout, they vary greatly in their alkali-content, and consequently in their felspars. Without going into too much detail the following percentages from analyses kindly made by Dr. H. F. Harwood are suggestive.

Lower lava of Miller's Dale area :—		
Lower part of flow . . .	K_2O, 6·77.	Na_2O, 1·75
Upper part of flow . . .	K_2O, 0·69.	Na_2O, 2·39
Upper lava of Matlock area . .	K_2O, 7·39.	Na_2O, 0·35
Lava near Cracknowl vent . .	K_2O, 1·07.	Na_2O, 2·33

The felspar of the potash-bearing basalts is orthoclase, that of the more normal basalts is labradorite. It will be seen that, *so far as alkali-content is concerned*, the former have the constitution of a granite.

Is it not possible that there may be a direct relation between this granitic feature of some of the lavas and the fluorine emanations, probably SiF_4, which have formed the deposits in question? In that case the ascensionist theory holds its own without the aid of a granite bathylith.

In a future paper, when the work is completed, I hope to show the distribution of these two types of lava over the whole of the Derbyshire area.

H. C. SARGENT.

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